

BUREAU OF DESIGN AND ENVIRONMENT MANUAL

Chapter Thirty-Eight ROADSIDE SAFETY

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CHAPTER THIRTY-EIGHT ROADSIDE SAFETY

The ideal roadway would be entirely free of any roadside obstructions or other hazardous conditions. This is rarely practical because of natural, economic, and environmental factors. Chapter 38 presents clear zone distances which should adequately provide a clear recovery area for 80 to 85 percent of errant vehicles that run off the road, and the chapter provides criteria for the use of roadside barriers, median barriers, and impact attenuators where providing the clear zone is not practical. The chapter also discusses the use of cost-effective methodologies to determine roadside safety treatments.

38-1 APPLICATION

This Section presents the IDOT application of roadside safety decisions based on project type and appurtenance type.

38-1.01 Project Type

The following summarizes the use of the *BDE Manual* for roadside safety applications based on the project type or project scope of work:

- 1. <u>New Construction/Reconstruction Projects</u>. Chapter 38 presents the roadside safety criteria for all new construction/reconstruction projects.
- 2. <u>3R Non-Freeway Projects</u>. Chapter 49 presents the roadside safety criteria for 3R rural and urban highway non-freeway projects.
- 3. <u>3R Freeway Projects</u>. Chapter 50 presents the roadside safety criteria for 3R freeway projects.
- 4. <u>Hazard Elimination Projects</u>. The IDOT Bureau of Operations is responsible for identifying the project scope of work for hazard elimination projects which use the Federal-aid funds set aside for highway safety improvements. The scope of work may include roadside safety improvements. In this case, the designer will use the criteria in Chapter 38 with the specific application determined on a case-by-case basis considering:
 - the crash patterns at the site,
 - the project scope as outlined by the Bureau of Operations,

- project budget, and
- estimated construction costs.
- 5. <u>Work Zones</u>. Chapter 55 presents the roadside safety criteria for work zones.

38-1.02 Appurtenance Type

The following summarizes the Department's roadside safety responsibilities based on type of appurtenance:

- 1. <u>Bridge Rails</u>. The IDOT Bureau of Bridges and Structures is responsible for establishing Department criteria for the selection and design of all bridge rails. The Bureau of Design and Environment is responsible for the roadside barrier and terminal section approaching the bridge rail.
- 2. <u>Traffic Control Devices</u>. The Bureau of Operations and the Bureau of Bridges and Structures are jointly responsible for establishing Department criteria for the design of structural supports for traffic control devices (e.g., breakaway bases for large signs). For the location of traffic control devices, the Bureau of Operations determines the initial placement, and the road designer ensures that the proposed location is compatible with the roadway design.
- 3. <u>All Other Appurtenances</u>. The Bureau of Design and Environment is responsible for establishing Department criteria for all other roadside safety appurtenances (e.g., roadside barriers, median barriers, impact attenuators, luminaires).

38-2 DEFINITIONS

- 1. <u>Back Slope</u>. The side slope created by connecting the ditch bottom, shelf, or shoulder at the hinge point, upward and outward, to the natural ground line.
- 2. <u>Barrier Terminals</u>. End treatments for both roadside barriers and transitions to other types of barriers (e.g., to bridge rails).
- 3. <u>Barrier Warrant</u>. A criterion that identifies an area of concern which should be shielded by a traffic barrier, if judged to be practical. The warrant may be based on IDOT/AASHTO guidelines, on a "cost-effective" assessment, or on engineering judgment.
- 4. <u>Concrete Barrier</u>. A rigid barrier constructed in a narrow median where no deflection distance is available and which can accommodate most vehicular impacts without penetration.
- 5. <u>Critical Parallel Slope</u>. Fill sections with front slopes steeper than 1V:3H that cannot be safely traversed by a run-off-the-road vehicle. Depending on the encroachment conditions, a vehicle on a critical slope may overturn.
- 6. <u>End Treatments</u>. The terminal devices for roadside barriers, including both the approaching and departing ends.
- 7. <u>Experimental System</u>. A roadside barrier, end terminal, or impact attenuator which has performed satisfactorily in full-scale crash tests but has not been installed in sufficient locations or exposed to traffic for a sufficient time to adequately evaluate its in-service performance.
- 8. <u>Front Slope</u>. The side slope created by connecting the shoulder or shelf at the hinge point, downward and outward, to the ditch bottom or natural ground line.
- 9. <u>Gating</u>. A term used to describe barrier end treatments which are designed to allow controlled penetration by an impacting vehicle.
- 10. <u>Impact Angle</u>. For a longitudinal barrier, the angle between a tangent to the face of the barrier and a tangent to the vehicular path at impact. For an impact attenuator, it is the angle between the axis of symmetry of the impact attenuator and a tangent to the vehicular path at impact.
- 11. <u>Impact Attenuator (Crash Cushion)</u>. A protective device used to safely shield roadside hazards, typically point obstacles, from approximately head-on impacts by errant vehicles.

- 12. <u>Length of Need</u>. Total length of a longitudinal barrier, measured with respect to the centerline of roadway, needed to shield an area of concern. The length of need is measured to the last point of full-strength rail.
- 13. <u>Median Barrier</u>. A longitudinal barrier used to prevent an errant vehicle from crossing the median of a divided highway thereby preventing head-on collisions between opposing traffic.
- 14. <u>Non-Recoverable Parallel Slope</u>. Slopes which can be safely traversed but upon which an errant vehicle is unlikely to recover. The run-off-the-road vehicle will likely continue down to the toe of the slope. For most embankment heights, if a front slope is between 1V:3H (inclusive) and 1V:4H (exclusive), it is considered a non-recoverable parallel slope.
- 15. <u>Non-Redirective</u>. A descriptive term which indicates that the roadside safety device will not redirect an impacting vehicle but will, rather, "capture" the vehicle (e.g., sand barrels) or allow the vehicle to pass through (e.g., breakaway sign supports).
- Operational System. A roadside barrier, end terminal, or crash cushion which has performed satisfactorily in full-scale crash tests and has demonstrated satisfactory inservice performance.
- 17. <u>Parallel Slopes</u>. Front and back slopes for which the toe runs approximately parallel to the roadway.
- 18. <u>Pocketing</u>. The potential for a vehicle impacting a redirective device to undergo relatively large lateral displacements within a relatively short longitudinal distance.
- 19. <u>Recoverable Parallel Slope</u>. Slopes which can be safely traversed and upon which a motorist has a reasonable opportunity to regain control of the vehicle. Front slopes 1V:4H and flatter are considered recoverable.
- 20. <u>Redirective</u>. A term which indicates that the roadside safety device is designed to redirect an impacting vehicle approximately parallel to the longitudinal axis of the device.
- 21. <u>Roadside Barrier</u>. A longitudinal barrier, such as guardrail, concrete barrier, etc., used to shield roadside hazards. A longitudinal barrier may occasionally be used to shield pedestrians from vehicular traffic.
- 22. <u>Roadside Clear Zones</u>. The distance beyond the edge of traveled way that should be clear of any non-traversable hazards or fixed objects.
- 23. <u>Roadside Hazards</u>. A general term to describe roadside features which cannot be safely impacted by a run-off-the-road vehicle. Roadside hazards include both fixed objects and non-traversable roadside features (e.g., rivers).

- 24. <u>Severity Index</u>. A number from zero to ten used to categorize crashes by the probability of their resulting in property damage, personal injury, or fatality, or any combination of these possible outcomes.
- 25. <u>Shy Distance</u>. The distance from the edge of traveled way beyond which a roadside object will not be perceived as an immediate hazard by the typical driver, to the extent that the driver will change vehicular placement or speed.
- 26. <u>Side Slope</u>. A ratio used to express the steepness of a slope adjacent to the roadway. The ratio is expressed as vertical to horizontal (V:H).
- 27. <u>Sloping Curb</u>. A longitudinal element, commonly called mountable curb, placed at the edge of traveled way to provide delineation, to control drainage, to manage access, and to outline corner islands. Sloping curbs have a height of 6 in (150 mm) or less with a sloping face of approximately 45°.
- 28. <u>Toe of Slope</u>. The intersection of the front slope or back slope with the natural ground line or ditch bottom, before any rounding is applied.
- 29. <u>Top of Slope</u>. The intersection of the back slope with the natural ground line, before any rounding is applied.
- 30. <u>Transverse Slopes</u>. Front and back slopes for which the toe runs approximately perpendicular to the flow of traffic on the major roadway. Transverse slopes are typically formed by intersections between the mainline and entrances, median crossovers, or side roads.
- 31. <u>Vertical Curb.</u> A longitudinal element, commonly called barrier curb, placed at the edge of the traveled way to provide delineation, to control drainage, to manage access, and to minimize right-of-way acquisition. Vertical curbs range in height between 6 in and 10 in (150 mm and 250 mm) with a face steeper than 3 vertical to 1 horizontal.

38-3 ROADSIDE CLEAR ZONES

38-3.01 Background

The clear zone widths presented in this *Manual* are based on limited empirical data which has then been extrapolated to a wide range of conditions. Therefore, the distances imply a degree of accuracy that does not exist. They do, however, provide a good frame of reference for making decisions on providing a safe roadside area. Each application of the clear zone distance must be evaluated individually, and the designer must exercise good judgment.

When using the recommended clear zone distances, the designer should consider the following:

- 1. <u>Project Scope of Work</u>. The clear zone distances in Section 38-3 apply to all freeway projects and to new construction/reconstruction projects on non-freeways. Chapter 49 presents the criteria for 3R projects on non-freeways.
- 2. <u>Context</u>. If a formidable obstacle lies just beyond the clear zone, it may be appropriate to remove or shield the obstacle if costs are reasonable. Conversely, the clear zone should not be achieved at all costs. Limited right-of-way (see 4 below) or unacceptable construction costs may lead to installation of a barrier or perhaps no protection at all. As a general statement, the use of an appropriate clear zone distance is a compromise between maximum safety and minimum construction costs.
- 3. <u>Boundaries</u>. The designer should not use the clear zone distances as boundaries for introducing roadside hazards such as bridge piers, non-breakaway sign supports, utility poles, or landscaping features. These should be placed as far from the traveled way as practical.
- 4. Right-of-Way. Even for new construction/reconstruction projects, the availability of right-of-way may be a serious project issue. The acquisition of additional right-of-way solely to provide the clear zone distance may not be cost effective. If, on the other hand, the right-of-way width exceeds the design clear zone, this offers an opportunity to increase safety by removing all hazards within the right-of-way.

38-3.02 Clear Zone Values

Figure 38-3A presents clear zone distances for design. The following discusses the use of the table to determine the applicable clear zone.

Design	Design Year	Front Slopes			Back Slopes			
Speed	ADT	1V:6H or Flatter	1V:5H to 1V:4H	1V:3H	1V:3H	1V:5H to 1V:4H	1V:6H or Flatter	
	Under 750	7 – 10	7 – 10	**	7 – 10	7 – 10	7 – 10	
40 mph or	750 – 1500	10 – 12	12 – 14	**	10 – 12	10 – 12	10 – 12	
less	1500 – 6000	12 – 14	14 – 16	**	12 – 14	12 – 14	12 – 14	
	Over 6000	14 – 16	16 – 18	**	14 – 16	14 – 16	14 – 16	
	Under 750	10 – 12	12 – 14	**	8 – 10	8 – 10	10 – 12	
45 – 50	750 – 1500	12 – 14	16 – 20	**	10 – 12	12 – 14	14 – 16	
mph	1500 – 6000	16 – 18	20 – 26	**	12 – 14	14 – 16	16 – 18	
	Over 6000	18 – 20	24 – 28	**	14 – 16	18 – 20	20 – 22	
	Under 750	12 – 14	14 – 18	**	8 – 10	10 – 12	10 – 12	
	750 – 1500	16 – 18	20 – 24	**	10 – 12	14 – 16	16 – 18	
55 mph	1500 - 6000	20 - 22	24 – 30	**	14 – 16	16 – 18	20 – 22	
	Over 6000	22 – 24	26 – 32*	**	16 – 18	20 – 22	22 – 24	
	Under 750	16 – 18	20 – 24	**	10 – 12	12 – 14	14 – 16	
	750 – 1500	20 – 24	26 – 32*	**	12 – 14	16 – 18	20 – 22	
60 mph	1500 – 6000	26 – 30	32 – 40*	**	14 – 18	18 – 22	24 – 26	
	Over 6000	30 – 32*	36 – 44*	**	20 – 22	24 – 26	26 – 28	
	Under 750	18 – 20	20 – 26	**	10 – 12	14 – 16	14 – 16	
65 – 70	750 – 1500	24 – 26	28 – 36*	**	12 – 16	18 – 20	20 – 22	
mph	1500 – 6000	28 – 32*	34 – 42*	**	16 – 20	22 – 24	26 – 28	
	Over 6000	30 – 34*	38 – 46*	**	22 – 24	26 – 30	28 – 30	

^{*} Clear zones may be limited to 30 ft for practicality and to provide a consistent roadway template.

Notes: 1. All distances are measured from the edge of the traveled way.

- 2. For clear zones, the "Design Year ADT" will be the total ADT for both directions of travel for the design year. This applies to both divided and undivided facilities. Traffic volumes will be based on a 20-year projection from the anticipated date of construction.
- 3. The values for "back slopes" only apply to a section where the toe of the back slope is adjacent to the shoulder. See Figure 38-3B(d). For sections with roadside ditches, see Section 38-3.04.
- 4. The values in the figure apply to tangent sections of highway. See the discussion in Section 38-3.02(e) for possible adjustments on horizontal curves.
- 5. The values in the figure apply to all uncurbed sections and curbed sections in rural areas. See Section 38-3.02(f) for curbed sections in urban areas.

RECOMMENDED CLEAR ZONE DISTANCES (ft) (New Construction/Reconstruction) (US Customary)

Figure 38-3A

^{**} See procedure in Section 38-3.03(b).

Design	Design Year	F	ront Slopes	Back Slopes			
Speed	ADT	1V:6H or Flatter	1V:5H to 1V:4H	1V:3H	1V:3H	1V:5H to 1V:4H	1V:6H or Flatter
60 km/h	Under 750	2.0 - 3.0	2.0 - 3.0	**	2.0 - 3.0	2.0 - 3.0	2.0 - 3.0
or or	750-1500	3.0 - 3.5	3.5 - 4.5	**	3.0 - 3.5	3.0 - 3.5	3.0 - 3.5
_	1500-6000	3.5 - 4.5	4.5 - 5.0	**	3.5 - 4.5	3.5 - 4.5	3.5 - 4.5
less	Over 6000	4.5 - 5.0	5.0 - 5.5	**	4.5 - 5.0	4.5 - 5.0	4.5 - 5.0
	Under 750	3.0 - 3.5	3.5 – 4.5	**	2.5 - 3.0	2.5 - 3.0	3.0 - 3.5
70-80	750-1500	4.5 - 5.0	5.0 - 6.0	**	3.0 - 3.5	3.5 - 4.5	4.5 - 5.0
km/h	1500-6000	5.0 - 5.5	6.0 - 8.0	**	3.5 - 4.5	4.5 - 5.0	5.0 - 5.5
	Over 6000	6.0 - 6.5	7.5 – 8.5	**	4.5 - 5.0	5.5 - 6.0	6.0 - 6.5
	Under 750	3.5 - 4.5	4.5 – 5.5	**	2.5 - 3.0	3.0 - 3.5	3.0 - 3.5
90 km/h	750-1500	5.0 - 5.5	6.0 - 7.5	**	3.0 - 3.5	4.5 - 5.0	5.0 - 5.5
90 KIII/II	1500-6000	6.0 - 6.5	7.5 - 9.0	**	4.5 - 5.0	5. 0 – 5.5	6.0 - 6.5
	Over 6000	6.5 - 7.5	8.0 – 10.0*	**	5.0 - 5.5	6.0 - 6.5	6.5 - 7.5
	Under 750	5.0 - 5.5	6.0 – 7.5	**	3.0 - 3.5	3.5 - 4.5	4.5 – 5.0
100 km/h	750-1500	6.0 - 7.5	8.0 – 10.0*	**	3.5 - 4.5	5.0 - 5.5	6.0 - 6.5
100 KIII/II	1500-6000	8.0 - 9.0	10.0 – 12.0*	**	4.5 - 5.5	5.5 - 6.5	7.5 - 8.0
	Over 6000	9.0 – 10.0*	11.0 – 13.5*	**	6.0 - 6.5	7.5 - 8.0	8.0 - 8.5
	Under 750	5.5 – 6.0	6.0 - 8.0	**	3.0 - 3.5	4.5 – 5.0	4.5 – 5.0
110 km/h	750-1500	7.5 - 8.0	8.5 – 11.0*	**	3.5 - 5.0	5.5 - 6.0	6.0 - 6.5
I IU KIII/II	1500-6000	8.5 – 10.0*	10.5 – 13.0*	**	5.0 - 6.0	6.5 - 7.5	8.0 - 8.5
	Over 6000	9.0 – 10.5*	11.5 – 14.0*	**	6.5 - 7.5	8.0 - 9.0	8.5 - 9.0

^{*} Clear zones may be limited to 9.0 m for practicality and to provide a consistent roadway template.

Notes: 1. All distances are measured from the edge of the traveled way.

- 2. For clear zones, the "Design Year ADT" will be the total ADT for both directions of travel for the design year. This applies to both divided and undivided facilities. Traffic volumes will be based on a 20-year projection from the anticipated date of construction.
- 3. The values for "back slopes" only apply to a section where the toe of the back slope is adjacent to the shoulder. See Figure 38-3B(d). For sections with roadside ditches, see Section 38-3.04.
- 4. The values in the figure apply to tangent sections of highway. See the discussion in Section 38-3.02(e) for possible adjustments on horizontal curves.
- 5. The values in the figure apply to all uncurbed sections and curbed sections in rural areas. See Section 38-3.02(f) for curbed sections in urban areas.

RECOMMENDED CLEAR ZONE DISTANCES (m) (New Construction/Reconstruction) (Metric) Figure 38-3A

^{**} See procedure in Section 38-3.03(b).

38-3.02(a) Speed

The designer will use the design speed for the facility to determine the applicable clear zone from Figure 38-3A.

38-3.02(b) Design Year

For all freeway projects and non-freeway new construction/reconstruction projects, the design year will be 20 years from the anticipated date of construction.

38-3.02(c) Traffic Volumes

As indicated in Figure 38-3A, the ADT influences the clear zone value. The figure is divided into ranges of traffic volumes and ranges of recommended clear zones. In general, the higher clear zones apply to the higher traffic volumes.

38-3.02(d) Side Slopes

The roadway side slope will influence the recommended clear zone distance from Figure 38-3A. Figure 38-3B presents a schematic of the general side slope configurations, which may include:

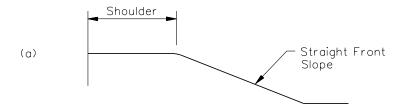
- a straight front slope,
- a variable or barn roof section,
- a section with a roadside ditch, or
- a section where the toe of the back slope is adjacent to the edge of shoulder.

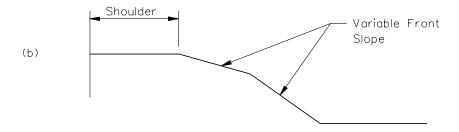
Note: The values in Figure 38-3A for back slopes only apply to a section as illustrated in Figure 38-3B(d); they do not apply where a roadside ditch is present.

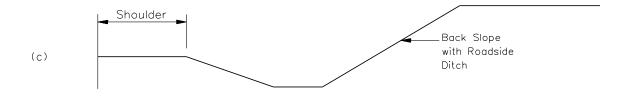
Many variables influence the selection of a clear zone distance for the various side slope configurations. Sections 38-3.03 and 38-3.04 discuss side slopes in detail.

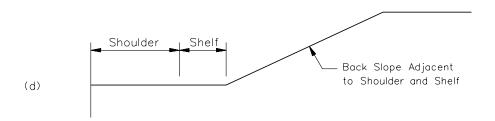
38-3.02(e) Alignment (Horizontal Curve Adjustment)

The clear zone values in Figure 38-3A assume a tangent alignment. Horizontal curves may increase the angle of departure from the roadway and thus increase the distance the vehicle will need to recover. Desirably and if practical, the designer should adjust the tangent values to provide wider clear zones on the outside of horizontal curves. It is unnecessary, however, to purchase additional right-of-way solely to provide the clear zone adjusted for horizontal









SIDE SLOPE CONFIGURATIONS

Figure 38-3B

curvature. Where adjustments are determined to be cost effective, Figure 38-3C illustrates the application of the clear zone adjustment on a curve. Figure 38-3D provides recommended adjustments for clear zones on horizontal curves.

* * * * * * * * * *

Example 38-3.02(1)

Given: Design Speed = 55 mph

Design ADT = 3000

Horizontal curve with a radius of 2000 ft

Flat side slope

Problem: Find the clear zone adjusted for the horizontal curve.

Solution: From Figure 38-3A, the clear zone on the tangent $(CZ_t) = 20$ ft.

From Figure 38-3D, the curve correction factor (K_{cz}) = 1.2 The clear zone for the curve (CZ_c) = (20)(1.2) = 24 ft (use 25 ft)

The transition length (equal to the runout length (L_R)) from Figure 38-6C = 345 ft.

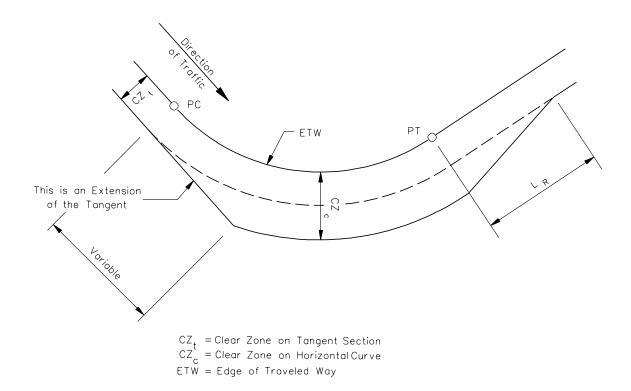
* * * * * * * * * *

38-3.02(f) Curbed Sections

The values in Figure 38-3A apply to uncurbed sections of highway. Where curbs are present, the following will apply:

1. <u>Urban/Suburban Facilities</u>. A minimum horizontal, obstruction-free clearance of 1.5 ft (500 mm) should be provided as measured from the gutter line of the curb. This applies to both vertical and sloping curbs, except that M2 (M5) curb will be treated as an uncurbed section. Because curbs are not considered to have re-directional capabilities, desirably and if practical, the designer should provide obstruction-free clearances beyond the curb greater than 1.5 ft (500 mm). Hazards behind curbs should be located outside of the clear zone shown for uncurbed roadways (i.e., Figure 38-3A) when practical.

As further discussed in Section 38-4, general Department policy is that roadside barriers are typically not warranted to shield hazards outside of the calculated clear zone. This also applies to hazards outside of the obstruction-free area behind curbs. However, special conditions may dictate otherwise. For example, a barrier may be required approaching all bridge rails on urban curbed facilities, unless the posted speed is 25 mph or less. Other exceptions, as determined on a case-by-case basis, may apply.



Note: See Figure 38-6C for L_R distances.

Radius			Des	ign Speed (n	nph)		
(ft)	40	45	50	55	60	65	70
2860	1.1	1.1	1.1	1.2	1.2	1.2	1.3
2290	1.1	1.1	1.2	1.2	1.2	1.3	1.3
1910	1.1	1.2	1.2	1.2	1.3	1.3	1.4
1640	1.1	1.2	1.2	1.3	1.3	1.4	1.5
1430	1.2	1.2	1.3	1.3	1.4	1.4	
1270	1.2	1.2	1.3	1.3	1.4	1.5	1
1150	1.2	1.2	1.3	1.4	1.5		•
950	1.2	1.3	1.4	1.5	1.5		
820	1.3	1.3	1.4	1.5			
720	1.3	1.4	1.5				
640	1.3	1.4	1.5				
570	1.4	1.5					
380	1.5						

Notes:

- 1. Adjustments apply to the <u>outside</u> of a horizontal curve only.
- 2. No adjustments are warranted for curve radii greater than 2860 ft.
- 3. The applicable clear zone distance on a horizontal curve is calculated by:

$$CZ_c = (K_{cz})(CZ_t)$$

where: CZ_c = clear zone on a curve, ft

 K_{cz} = curve adjustment factor

 CZ_t = clear zone on a tangent section from Figure 38-3A, ft

Round calculated CZ_c up to the next highest 1 ft increment.

- 4. For curve radii intermediate in the figure, use a straight-line interpolation.
- 5. See Figure 38-3C for the application of CZ_c to the roadside around a curve.

CLEAR ZONE ADJUSTMENT FACTORS FOR HORIZONTAL CURVES (Kcz) (US Customary)

Figure 38-3D

Radius		Design Speed (km/h)					
(m)	60	70	80	90	100	110	
900	1.1	1.1	1.1	1.2	1.2	1.2	
850	1.1	1.1	1.1	1.2	1.2	1.3	
800	1.1	1.1	1.1	1.2	1.2	1.3	
750	1.1	1.1	1.1	1.2	1.2	1.3	
700	1.1	1.1	1.2	1.2	1.2	1.3	
650	1.1	1.2	1.2	1.2	1.3	1.4	
600	1.1	1.2	1.2	1.2	1.3	1.4	
550	1.1	1.2	1.2	1.3	1.3	1.4	
500	1.1	1.2	1.2	1.3	1.3	1.4	
450	1.2	1.2	1.3	1.3	1.4		
400	1.2	1.2	1.3	1.3	1.4		
350	1.2	1.2	1.3	1.4		_	
300	1.2	1.3	1.4	1.5			
250	1.3	1.3	1.4		•		
200	1.3	1.4		1			
150	1.4	1.5					
100	1.5		•				

Notes:

- 1. Adjustments apply to the <u>outside</u> of a horizontal curve only.
- 2. No adjustments are warranted for curve radii greater than 900 m.
- 3. The applicable clear zone distance on a horizontal curve is calculated by:

$$CZ_c = (K_{cz})(CZ_t)$$

where: CZ_c = clear zone on a curve, m

 K_{cz} = curve adjustment factor

 CZ_t = clear zone on a tangent section from Figure 38-3A, m

Round calculated CZ_c up to the next highest 0.5 m increment.

- 4. For curve radii intermediate in the figure, use a straight-line interpolation.
- 5. See Figure 38-3C for the application of CZ_c to the roadside around a curve.

CLEAR ZONE ADJUSTMENT FACTORS FOR HORIZONTAL CURVES (Kcz) (Metric)

2. <u>Rural Facilities</u>. For specific field conditions, it may be acceptable to use sloping curbs on rural facilities. See Chapter 34. However, the clear zone will be determined assuming that the facility is uncurbed; i.e., the clear zone criteria presented in Chapter 38 will apply to all rural facilities whether curbed or uncurbed.

38-3.02(g) Lane Width

The clear zone distances in Figure 38-3A are, theoretically, predicated upon a 12 ft (3.6 m) lane width. However, they will be used for any lane width.

38-3.02(h) Auxiliary Lanes

Auxiliary lanes are defined as any lanes beyond the basic through travel lanes which are intended for use by vehicular traffic for specific functions. These include turn lanes at intersections, truck-climbing lanes, weaving lanes, acceleration/deceleration lanes at interchanges, etc. The clear zone for auxiliary lanes will be determined as follows:

- 1. <u>Turn Lanes at Intersections</u>. Where the intersection is uncurbed, clear zones will be determined based on the design speed and traffic volumes associated with the through travel lanes; i.e., the presence of the turn lane is ignored when determining clear zones, provided that a minimum 10 ft (3.0 m) clear zone is maintained beyond the edge of the shoulder. Where the intersection is curbed, the criteria in Section 38-3.02(f) will apply; i.e., the minimum obstruction-free zone is 1.5 ft (500 mm) from the gutter line.
- 2. <u>Auxiliary Lanes Adjacent to Mainline</u>. Clear zone applications for climbing lanes, acceleration/deceleration lanes, ramp terminals, weaving lanes, etc., shall be as follows. Two independent clear zone determinations are necessary. First, the designer calculates the clear zone from the edge of the through traveled way based on the total traffic volume, including the auxiliary lane volume. Second, the designer calculates the clear zone from the edge of the auxiliary lane based on the traffic volume in the auxiliary lane. The clear zone distance which extends further will apply.

38-3.03 Front Slopes

Figure 38-3B illustrates the two basic configurations for front slopes (i.e., straight slope or variable slope). Section 38-2 presents definitions of parallel front slopes which apply to clear zone determinations. Figure 38-3E presents schematics for these definitions, and the following discusses the clear zone application in conjunction with Figure 38-3A.

38-3.03(a) Recoverable Front Slopes

For parallel front slopes 1V:4H and flatter (Figure 38-3E(a)), the recommended clear zone distance can be determined directly from Figure 38-3A.

38-3.03(b) Non-Recoverable Front Slopes

For parallel front slopes steeper than 1V:4H but 1V:3H or flatter (Figure 38-3E(b)), the recommended clear zone includes a distance beyond the toe of the slope. Use the following procedure to determine the clear zone:

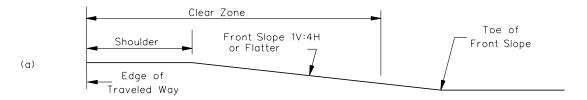
- 1. Determine the clear zone for a 1V:6H or flatter slope from Figure 38-3A for the applicable design speed and traffic volume.
- 2. To determine the recommended distance beyond the toe, subtract the shoulder width (or the distance from the edge of traveled way to the slope break) from the distance in Step #1.
- 3. If the distance in Step #2 is less than 10 ft (3 m), the minimum clear distance will be 10 ft (3 m) beyond the toe. If the distance in Step #2 is greater than 10 ft (3 m), the clear distance beyond the toe will be that distance or 15 ft (5 m), whichever is less.

38-3.03(c) Barn-Roof Front Slope (Recoverable/Non-Recoverable)

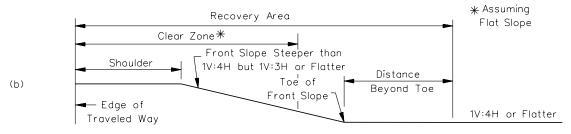
Barn-roof front slopes may be designed with a recoverable slope leading to a non-recoverable slope (Figure 38-3E(c)). The distance from the break between the two slopes to the clear zone (noted as "X" on Figure 38-3E(c)) should be applied as an addition outside the toe of the non-recoverable slope. This addition should be a minimum of 10 ft (3 m) wide; i.e., a clear area beyond the toe of slope (10 ft (3 m) minimum) will be needed where the clear zone extends beyond the break between the recoverable and non-recoverable slopes. The maximum clear zone area beyond the toe of slope will be 15 ft (5 m). If the distance from the edge of traveled way to the break between the two slopes is a minimum of 30 ft (9 m), no additional clear area will be required at the toe of slope.

38-3.03(d) Barn-Roof Front Slope (Recoverable)

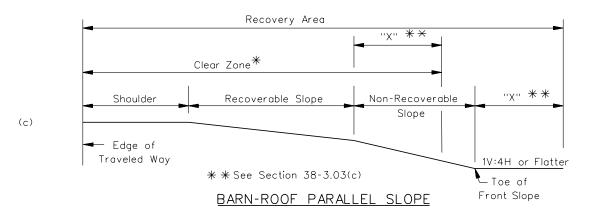
Barn-roof front slopes are slopes designed with two recoverable slope rates — the second slope is steeper than the slope adjacent to the shoulder. This design requires less right-of-way and embankment material than a continuous, flatter slope. Although a "weighted" average of the slopes may be used, a simple average of the clear zone distances for each slope is sufficiently accurate, if the variable slopes are approximately the same width. If one slope is significantly wider, the clear zone computation based on that slope alone may be used.

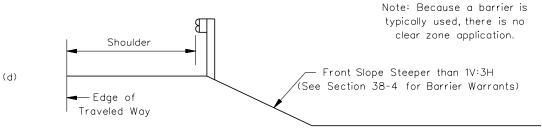


RECOVERABLE PARALLEL SLOPE



NON-RECOVERABLE PARALLEL SLOPE





CRITICAL PARALLEL SLOPE

CLEAR ZONE APPLICATION FOR FRONT SLOPES (Uncurbed)

Figure 38-3E

38-3.03(e) Critical Front Slope

Front slopes steeper than 1V:3H are critical (Figure 38-3E(d)). These typically require a barrier and, therefore, there is no clear zone application. See Section 38-4.

Example 38-3.03(1) (Recoverable Front Slope)

Given: Front Slope — 1V:4H

> Design Speed — 60 mph Design ADT — 7000

Problem: Determine the recommended clear zone distance.

Solution: From Figure 38-3A, the clear zone distance should be 36 ft to 44 ft. However, as

indicated in a footnote to the figure, the clear zone distance may be limited to

30 ft based on specific site conditions to provide a more practical design.

Example 38-3.03(2) (Non-Recoverable Front Slope)

Given: Front Slope — 1V:3H

> Shoulder Width — 10 ft Design Speed — 60 mph Design ADT — 7000

Problem: Determine the recommended clear zone distance.

Solution: The procedure in Section 38-3.03(b) for non-recoverable front slopes is used as

follows:

1. From Figure 38-3A, the clear zone for a front slope 1V:6H or flatter is 30 ft to 32 ft.

2. The recommended clear distance beyond the toe of the non-recoverable slope (1V:3H)

is (30 ft to 32 ft) minus 10 ft yields (20 ft to 22 ft).

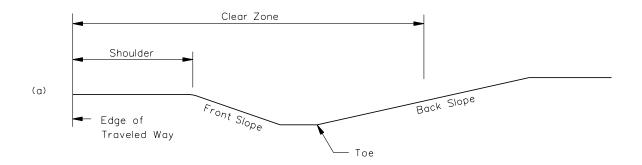
3. The calculated clear distance beyond the toe is 20 ft to 22 ft; however, the maximum distance is 15 ft.

* * * * * * * * *

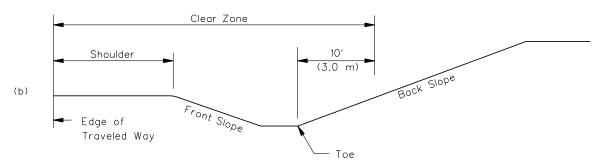
38-3.04 Roadside Ditches

Ditch sections, as illustrated in Figure 38-3F, are typically constructed in roadside cut sections without curbs. The applicable clear zone across a ditch section will depend upon the front slope, the back slope, the horizontal location of the toe of the back slope, and various highway factors. The designer will use the following procedure to determine the recommended clear zone distance:

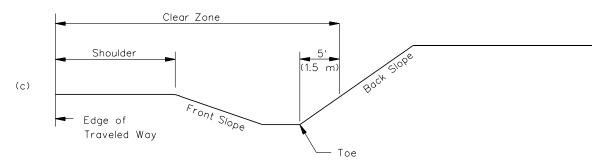
- 1. <u>Check Front Slope</u>. Use Figure 38-3A to determine the clear zone based on the ditch front slope.
- 2. <u>Check Location of the Toe of Back Slope</u>. Based on the distance from Step #1, determine if the toe of the back slope is within the clear zone. The toe of back slope is defined as the point at which the ditch rounding ends and the (uniform) back slope begins. If the toe is at or beyond the clear zone, then the designer usually need only consider roadside hazards within the clear zone on the front slope or within the ditch. If the toe is within the clear zone, the designer should evaluate the practicality of relocating the toe of back slope. If the toe of back slope will remain within the clear zone, Step #3 below will apply to ditch sections in earth cuts.
- 3. <u>Determine Clear Zone on Back Slope (Earth Cuts)</u>. If the toe of the back slope is within the clear zone distance from Step #1 above, a clear zone should be provided on the back slope. This clear zone will be a distance beyond the toe of back slope as follows:
 - a. When the back slope is 1V:6H or flatter (Figure 38-3F(a)), treat the back slope as level and use the clear zone based on the front slope rate to determine the clear zone limit on the back slope.
 - b. When the back slope is steeper than 1V:6H but 1V:3H or flatter (Figure 38-3F(b)), assume the vehicle cannot make it up to the top of the back slope, if the slope is at least 10 ft (3 m) wide. The initial 10 ft (3 m) beyond the toe of the back slope or the distance in Step #3a, whichever is less, should be clear of roadside hazards. Any obstacles beyond this point would be considered outside of the clear zone.
 - c. When the back slope is steeper than 1V:3H (Figure 38-3F(c)), the initial 5 ft (1.5 m) beyond the toe of the back slope should be clear of roadside hazards.
- 4. <u>Clear Zones (Rock Cuts)</u>. In rock cuts with steep back slopes, no clear zone is required beyond the toe of back slope. However, the rock cut should be relatively smooth to minimize the hazards of vehicular snagging. If the face of the rock is rough or rock debris is present, a barrier may be warranted.



BACK SLOPE 1V:6H OR FLATTER



BACK SLOPE STEEPER THAN 1V:6H BUT 1V:3H OR FLATTER



BACK SLOPE STEEPER THAN 1V:3H

CLEAR ZONE APPLICATION FOR ROADSIDE DITCHES

Figure 38-3F

* * * * * * * * * *

Example 38-3.04(1) (Ditch Section)

Given: Design ADT = 7000

V = 60 mph

Front Slope = 1V:6H Ditch Width = 4 ft Back Slope = 1V:4H

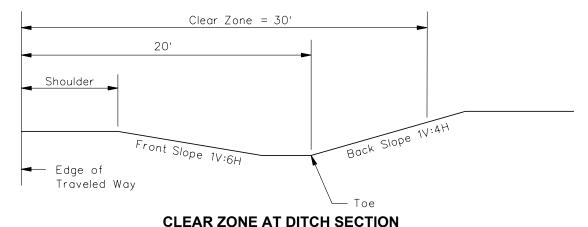
Toe of back slope is 20 ft from edge of traveled way.

See Figure 38-3G.

Problem: Determine the clear zone application across the ditch section.

Solution: Using the procedure in Section 38-3.04:

- 1. <u>Check Front Slope</u>. Figure 38-3A yields a clear zone of 30 ft to 32 ft for a 1V:6H front slope. However, as indicated in the footnote, a 30-ft clear zone may be used.
- 2. <u>Check Location of Toe of Back Slope</u>. The toe of back slope is within the clear zone. Therefore, Step #3 applies.
- 3. <u>Determine Clear Zone on Back Slope (Earth Cuts)</u>. With a 1V:4H back slope, the criteria in Step #3b in the procedure will apply. Based on these criteria, the initial 10 ft beyond the toe of back slope should be clear of roadside hazards. This yields a total distance of 35 ft from the edge of traveled way. Therefore, use the lower number from Step #2 and Step #3, which yields a 30 ft clear zone for the roadside.



(Example 38-3.04(1))

Figure 38-3G

38-4 ROADSIDE BARRIER WARRANTS

38-4.01 Examples of Roadside Hazards

Examples of roadside hazards include:

- non-breakaway sign supports, non-breakaway luminaire supports, traffic signal poles, and railroad signal poles;
- concrete footings, etc., extending more than 4 in (100 mm) above the ground;
- bridge piers and abutments at underpasses and bridge parapet ends;
- culvert headwalls;
- trees with diameters greater than 4 in (100 mm) (at maturity);
- rough rock cuts;
- large boulders;
- critical parallel slopes (i.e., embankments);
- streams or permanent bodies of water (where the depth of water ≥ 2 ft (600 mm));
- non-traversable ditches;
- utility poles or towers;
- drainage appurtenances; and
- steep transverse slopes.

The severity of a specific roadside hazard will depend upon many factors. Appendix A of the AASHTO *Roadside Design Guide* presents Severity Indices (SI) for a variety of roadside hazards. The SI provides an indication of the relative severity of impacting the hazard compared to other roadside hazards.

38-4.02 Range of Treatments

If a roadside hazard is within the clear zone, the designer should select the treatment which is judged to be the most practical and cost-effective for the site conditions. The range of treatments include:

- eliminate the hazard (flatten embankment, remove rock outcroppings, etc.);
- relocate the hazard;
- where applicable, make the hazard breakaway (sign posts, luminaire supports);
- shield the hazard with a roadside barrier;
- delineate the hazard; or
- do nothing.

38-4.03 Warrant Methodologies

In many cases, the alternatives for treating a roadside hazard may be narrowed to two choices — install a barrier or do nothing. Whether objectively or subjectively, the decision will be based upon the traffic volumes, roadway geometry, proximity of the hazard to the traveled way, nature of the hazard, installation costs and, where applicable, crash experience. The following briefly discusses the Department's decision-making methods for barrier warrants.

38-4.03(a) Department Policy

For specific applications, the Department has adopted policies on warrants for roadside barriers. These are documented throughout Section 38-4. For example, Department policy is that, for bridge rail ends, an approaching roadside barrier will be installed unless the posted speed limit is less than 25 mph on an urban curbed section.

38-4.03(b) Cost-Effectiveness Method

Where practical, the designer should use an approved cost-effectiveness methodology to determine roadside barrier warrants. This will provide an objective means to analyze the myriad factors which impact roadside safety, and it will, in theory, allow the Department to allocate its resources to maximize the safety benefit to the traveling public. It will also promote uniformity of decision-making for roadside safety throughout the Department. The designer must use a cost-effectiveness methodology which has been approved by the Bureau of Design and Environment. Currently, IDOT generally uses the cost-effectiveness methodology Roadside Safety Analysis Program (RSAP) presented in Appendix A of the AASHTO Roadside Design Guide.

38-4.03(c) Engineering Judgment Method

Until the development of cost-effectiveness models, barrier warrants were typically determined based on engineering judgment. With this approach, the designer first analyzes the site by a "relative severity" assessment — which is the greater hazard, the roadside barrier or the roadside hazard? Next, the designer subjectively evaluates the site-specific parameters (e.g.,

traffic volumes, design speed, location of hazard, barrier installation costs) to determine if a barrier installation is a reasonable and practical solution. If yes, a barrier is warranted; if no, the do-nothing alternative is selected. For example, it would probably not be practical to install a barrier to shield an isolated point obstacle, such as a tree, located near the edge of the clear zone. The designer must realize that a barrier is also a hazard and, if a clear decision cannot be reached, the general rule of "when in doubt, leave it out" should apply.

It is acceptable to use engineering judgment to determine the warrants for roadside barriers for two conditions:

- 1. If the decision is obvious for a specific site, the designer may forego the use of a costeffectiveness method and use his/her judgment to install or not install a roadside barrier.
- 2. If extenuating circumstances exist, the designer may override Department policies for barrier warrants or the results of a cost-effectiveness method, either to install or not install a roadside barrier. In this case, the designer must document the reasons for his/her decision. This documentation should include crash histories for the section of roadway, traffic volumes, posted speed, and roadway geometry.

38-4.04 Embankments

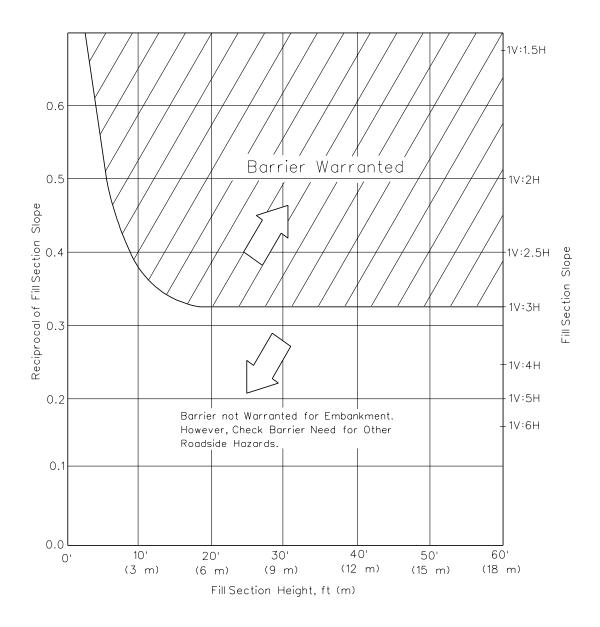
Figure 38-4A presents barrier warrants for embankments.

38-4.05 Transverse Slopes

Where the mainline highway intersects an entrance, side road, or median crossing, a slope transverse to the mainline will be present. See Figure 38-4B. In general, transverse slopes should be as flat as practical. Figure 38-4C presents IDOT criteria for transverse slopes within the clear zone based on type of facility and design speed.

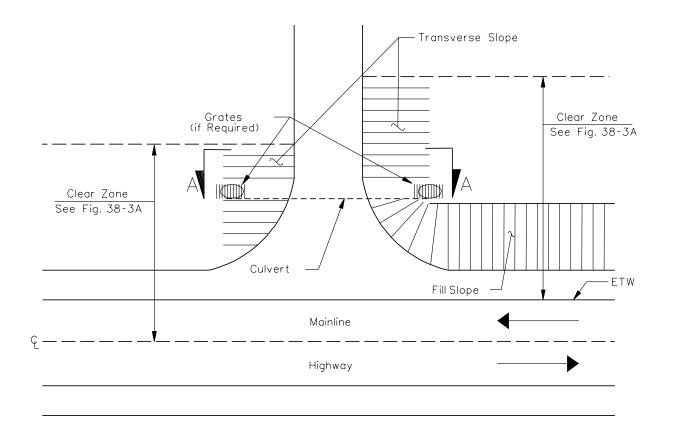
Figure 38-4C presents both desirable (i.e., flatter) and acceptable (i.e., steeper) transverse slopes. The application at a specific site will depend upon an evaluation of many factors, including:

- height of transverse embankment,
- traffic volumes,
- design speed,
- presence of culverts and practicality of treating the culvert end (see Section 38-4.06),
- construction costs, and
- right-of-way and environmental impacts.

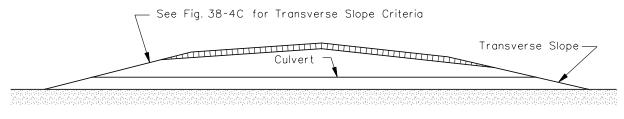


Note: Points which fall on the solid line do not warrant a barrier.

BARRIER WARRANTS FOR EMBANKMENTS Figure 38-4A



Note: On a one-way facility, the grate on the departure end is not required.



SECTION A-A

TRANSVERSE SLOPES ON A TWO-LANE, TWO-WAY ROADWAY Figure 38-4B

Although the 1V:10H transverse slope may be desirable, its practicality may be limited because of drainage structures, width restrictions, and maintenance problems associated with the long tapered ends of pipes or culverts. On arterial highways including freeways, however, the 1V:10H transverse slope should be used unless regrading of existing 1V:6H transverse slopes would require the installation of new drainage features.

If the criteria in Figure 38-4C cannot be met, the designer should consider the installation of a roadside barrier.

Type of Facility	Desirable (V:H)	Acceptable (V:H)
Freeway	1:10	1:6
Rural Non-Freeways (V ≥ 50 mph (80 km/h))	1:10	1:6
Urban Non-Freeways (V ≥ 50 mph (80 km/h))	1:6	1:4
Urban and Rural Low-Speed Facilities (V ≤ 45 mph (70 km/h))	1:6	1:4

RECOMMENDED TRANSVERSE SLOPES

Figure 38-4C

38-4.06 Roadside Drainage Features

Effective drainage is one of the most critical elements in the design of a highway or street. However, drainage features should be designed and constructed considering their consequences on run-off-the-road vehicles. Ditches, curbs, culverts, and drop inlets are common drainage system elements that should be designed, constructed, and maintained considering both hydraulic efficiency and roadside safety.

In general, the following options, listed in order of preference, are applicable to all drainage features:

- 1. Design or modify drainage structures so that they are traversable or present a minimal hazard to an errant vehicle.
- 2. If a major drainage feature cannot effectively be redesigned or relocated, shielding by a traffic barrier should be considered.

The *Illinois Drainage Manual* and Chapter 40 of the *BDE Manual* discuss the Department's practices for hydrology and hydraulics and for the physical design of roadside drainage structures. Sections 38-4.06(b) and (c) discuss the safety design of these structures.

38-4.06(a) Curbs

Curbs are typically used to control drainage or to protect erodible soils. Chapter 34 and the *IDOT Highway Standards* provide detailed information on the warrants and types of curbs used by the Department. Curbs may pose a roadside hazard because of their potential to adversely affect a run-off-the-road vehicle. When evaluating curbs relative to roadside safety, the designer should consider the following:

- 1. <u>Design Speed</u>. Facilities with a design speed greater than 45 mph (70 km/h) should be designed without curbs. However, if necessary, a sloping curb may be used. Facilities with a design speed of 45 mph (70 km/h) or less may use either a sloping or vertical curb. See Chapter 34.
- 2. <u>Roadside Barriers</u>. The use of curbs with a roadside barrier is discouraged and, specifically, curbs higher than 6 in (150 mm) should not be used with a barrier. See Section 38-6.03.
- 3. <u>Redirection</u>. Curbs offer no safety benefits on high-speed roadways and should not be used to redirect errant vehicles.
- 4. <u>M2 (M5) Curb</u>. It is acceptable to use the 2 in (50 mm) high M2 (M5) curb in conjunction with a roadside barrier.

38-4.06(b) Cross Drainage Structures

Cross drainage structures convey water beneath the roadway and are designed to, among other objectives, prevent overtopping of the roadway. However, if not properly designed, they may present a hazard to run-off-the-road vehicles. The available roadside safety treatments for cross culverts are:

- extend the culvert opening beyond the clear zone,
- provide a traversable end section,
- shield the culvert with a roadside barrier, or
- do nothing.

The following summarizes Department practices on the roadside safety treatment of cross drainage structures within the clear zone:

- 1. <u>Pipe Diameter ≤ 36 in (915 mm)</u>. For these pipe sizes, provide an end treatment which matches the existing parallel slope.
- 2. Pipe Diameter > 36 in (915 mm) to \leq 54 in (1400 mm). For these pipe sizes, provide a precast end section with grate.
- 3. <u>Pipe Diameter > 54 in (1400 mm)</u>. For these pipe sizes, provide a special end section with a grate designed in accordance with Chapter 3 of the AASHTO *Roadside Design Guide* or provide a roadside barrier.

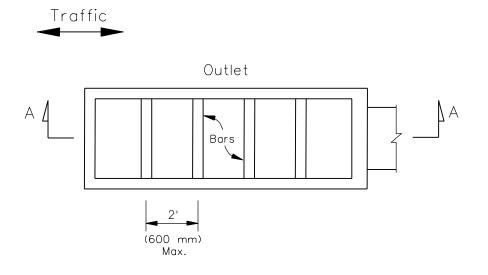
For pipe arches and elliptical pipes, the pipe rise will be used, rather than the equivalent round diameter, to determine the safety treatment. For box culverts, special designs for the end treatment will be required depending on the rise and span of the culvert. The type of treatment should be similar to that shown above for pipe culverts.

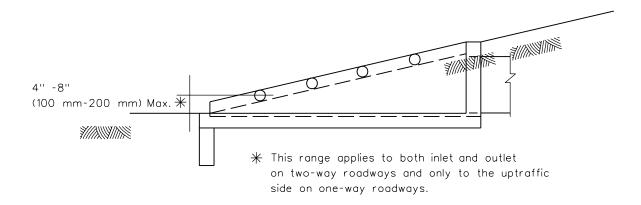
38-4.06(c) Parallel Drainage Structures

Parallel drainage culverts are those which are oriented parallel to the main flow of traffic. They are typically used under driveways, field entrances, access ramps, intersecting side roads, and median crossovers. Because an errant vehicle will impact the structure at approximately 90°, parallel drainage structures represent a potential hazard. Therefore, the designer must coordinate their design with that of the surrounding transverse slope (Section 38-4.05) to minimize the hazard.

The following summarizes Department practices on the roadside safety treatment of parallel drainage structures within the clear zone:

- 1. Pipe Diameter ≤ 18 in (450 mm). For these pipe sizes, a projecting end is acceptable.
- 2. <u>Pipe Diameter > 18 in to \le 24 in (450 mm to \le 600 mm)</u>. For these pipe sizes, the end of the pipe should match the slope of the surrounding transverse slope. The opening to the pipe may remain.
- 3. Pipe Diameter > 24 in (600 mm). For these pipe sizes, the end of the pipe should match the surrounding transverse slope, and the designer should provide a grate across the opening. This will reduce wheel snagging if an errant vehicle impacts the pipe end. Figure 38-4D presents a schematic of a design for grate protection of a parallel drainage structure.
- 4. <u>Pipe Arches and Elliptical Pipes</u>. The pipe rise may be used rather than the equivalent round diameter to determine the appropriate end treatment in accordance with the above practices.





SECTION A-A

DESIGN FOR PARALLEL DRAINAGE STRUCTURES (Diameter > 24 in (600 mm)) Figure 38-4D

- 5. <u>Box Culverts</u>. The distance from the flow line of the culvert to the top of the headwall will be used to determine the appropriate treatment. If the span of the box culvert is > 5 ft (1.5 m), a special end treatment must be developed regardless of the height. Consult the Bureau of Design and Environment for assistance in designing the end treatment.
- 6. <u>Eliminate Exposed Ends</u>. Parallel drainage structures may be closely spaced because of frequent driveways and intersecting roads. In such locations, it may be desirable to convert the open ditch into a closed drainage system and backfill the areas between adjacent driveways. This treatment will eliminate the ditch section and the transverse embankments with pipe inlets and outlets. However, care must be used to avoid creation of open frontage which would allow uncontrolled access.

38-4.07 Roadside Ditches (Earth Cuts)

The Department's configuration for roadside ditches in earth cuts, typically, is a trapezoidal ditch with the following dimensions:

- a 1V:6H front slope,
- a 4-ft (1.2-m) ditch width, and
- a 1V:3H back slope.

In the absence of other information (e.g., crash data), a roadside barrier is not warranted for the typical ditch configuration. The following additional information applies to roadside ditches in earth cuts:

- Other Configurations. For other ditch configurations which introduce a more abrupt vehicular change in direction, the designer should refer to the AASHTO Roadside Design Guide to judge the acceptability of the proposed ditch. If this indicates a potential safety problem, the designer should conduct a cost-effectiveness analysis to determine:
 - if a revised ditch configuration is appropriate,
 - if a roadside barrier is warranted, or
 - if the do-nothing alternative is appropriate.
- 2. <u>Deep Cuts</u>. For earth cuts where the height of the cut from the bottom of the ditch is greater than 10 ft (3.0 m), the designer may consider using a 1V:2H back slope above the 10 ft (3.0 m) elevation to reduce costs.

38-4.08 Rock Cuts

The Department's configuration for rock cuts, typically, is the following:

- a 1V:6H front slope,
- a 1.5 ft (500 mm) plus width for falling rock ditch, and
- a 1V:0.25H back slope or as required by rock type.

If the toe of the rock cut is outside of the clear zone, a roadside barrier is not warranted unless other information (e.g., crash data) indicates otherwise. If the toe is within the clear zone, the designer should conduct a cost-effectiveness analysis to determine:

- if the rock cut should be relocated outside of the clear zone,
- if a roadside barrier is warranted, or
- if the do-nothing alternative is appropriate.

38-4.09 Bridge Rails

Barrier protection is normally warranted on all approach ends to bridge rails or parapets, and it is normally warranted on the departure ends of two-way roadways. No roadside barrier is needed on the departure end of a one-way roadway, unless a barrier is warranted for other reasons (e.g., front slopes steeper than 1V:3H).

Clear zones begin at the edge of the traveled way. As such, the departure end of a bridge parapet is within the clear zone of the opposing traffic and should be shielded. At a minimum, an approved end section and attachment to the bridge shall be provided unless a cost-effective economic or other analysis shows shielding is not necessary. If other hazards, such as a permanent body of water more than 2 ft (600 mm) deep exist, then additional guardrail will be required. To determine the required length of need, use the $L_{\rm C}$ for the approach end measured from the edge of traveled way of the approaching end. $L_{\rm B}$ and the departing point for $L_{\rm R}$ will be measured from the center line. (See Figures 38-6A and 38-6B for definitions of $L_{\rm C}$, $L_{\rm B}$, and $L_{\rm R}$).

38-4.10 Retaining Walls

Barrier protection is not necessary for retaining walls which are considered "smooth" (i.e., the general absence of any unevenness in the wall which may adversely affect an impacting vehicle). Retaining walls built of sheet piling, H-piling with timber, or precast concrete inserts are usually considered smooth. In addition, the following will apply to the roadside safety aspects of retaining walls:

- 1. <u>Flare Rates</u>. Use the same rates as those for concrete barrier. See Figure 38-6L.
- 2. <u>End Treatment</u>. Preferably, the retaining wall will be buried in a back slope thereby shielding its end. If this is not practical, use a crashworthy end treatment or impact attenuator. Where the design speed is 35 mph (60 km/h) or less, it is acceptable to transition the top of the wall from its normal height down to the ground line.

38-4.11 Traffic Control Devices

Traffic control devices include highway signs and traffic signals. If not properly designed and located, these devices may become a hazard to errant vehicles. The Bureau of Operations is responsible for the initial placement of traffic control devices, based on proper conveyance of information to the motorist, and the road designer reviews the location to ensure that it is compatible with the roadway design.

38-4.11(a) Highway Signs

For roadside safety applications, the following will apply to highway signs:

- 1. <u>Design</u>. The *Illinois Highway Standards* and *Sign Structures Manual* contain the Department's details for structural supports for traffic control devices.
- 2. Ground-Mounted Sign Supports. All supports for ground-mounted signs should be made breakaway or yielding, including those outside of the clear zone. Where practical, the designer should locate signs behind a roadside barrier which is warranted for other reasons. There should be adequate clearance to the back of the guardrail post to provide for the barrier dynamic deflection (see Section 38-6.02). In addition, sign supports should not be placed in drainage ditches where erosion and freezing might affect the proper operation of breakaway supports. It is also possible that a vehicle entering the ditch might be inadvertently guided into the support.
- 3. Ground-Mounted Panel Signs. Large signs (over 50 ft² (5.0 m²) in area) should have slipbase breakaway supports, whether within or outside the clear zone. Where practical, the designer should locate signs behind a roadside barrier which is warranted for other reasons. There should be adequate clearance to the back of the guardrail post to provide for the barrier dynamic deflection (see Section 38-6.02). Panel signs should not be placed in areas where the opportunity exists for them to be struck more than 9 in (230 mm) above the normal point of vehicular bumper impact, unless the sign is at least 7 ft (2.1 m) above the ground line. Normal bumper height is 18 in (460 mm). To avoid signs being struck at an improper height, they should be placed as follows:
 - a. Front Slopes Flatter than 1V:4H. Signs should be located a minimum of 30 ft (9.0 m) from the edge of traveled way to the nearest edge of the sign.

b. Front Slopes 1V:4H or Steeper. The nearest sign edge should be located 6 ft (1.8 m) from the edge of shoulder or 12 ft (3.6 m) from the edge of traveled way, whichever is greater.

Breakaway sign supports should not be located in or near the flow line of ditches. If these supports are placed on a back slope, they should be offset at least 5 ft (1.5 m) from the toe of the back slope of the ditch.

4. <u>Overhead Sign Supports</u>. All overhead signs will use non-breakaway supports. Within the clear zone, the designer should conduct a cost-effectiveness analysis to determine if these structures should be protected with a roadside barrier or, where applicable, with an impact attenuator.

38-4.11(b) Traffic Signal Equipment

In general, the designer has limited options available in determining acceptable locations for the placement of signal pedestals, signal poles, pedestrian detectors, and controllers. Considering roadside safety, these elements should be placed as far from the roadway as practical. However, due to visibility requirements, limited mast-arm lengths, limited right-of-way, restrictive geometrics, or pedestrian requirements, traffic signal equipment often must be placed relatively close to the traveled way. The designer should consider the following when determining the placement of traffic signal equipment:

- 1. <u>Clear Zones</u>. If practical, the placement of traffic signals on new construction and reconstruction projects should meet the clear zone criteria (uncurbed) or obstruction-free clearance criteria (curbed) presented in Section 38-3.
- 2. <u>Controller</u>. In determining the location of the controller cabinet, the designer should consider the following:
 - a. The controller cabinet should be placed in a position so that it is unlikely to be struck by errant vehicles. It should be outside the clear zone or obstruction-free zone, if practical.
 - b. The controller cabinet should be located where it can be easily accessed by maintenance personnel.
 - c. The controller cabinet should be located so that a technician working in the cabinet can see the signal indications in at least one direction.
 - d. The controller cabinet should be located where the potential for water damage is minimized.
 - e. The controller cabinet should not obstruct intersection sight distance.

- f. The power service connection should be reasonably close to the controller cabinet.
- 3. <u>Pedestrians</u>. If the signal pole must be located in the sidewalk, it should be placed to minimize pedestrian conflicts. In addition, the signal pole shall not be placed such that it will restrict a handicapped individual's access to curb ramps. See Chapter 58.

38-4.12 Luminaires

Because of the potential hazard posed to vehicles by roadside fixed objects, the general approach to lighting standards will be to use breakaway supports wherever possible. All new lighting standards located within the clear zone of a roadway where no pedestrian facilities exist will be placed on breakaway supports, unless they are located behind or on a barrier or protected by impact attenuators which are necessary for other roadside safety reasons. Poles outside the clear zone on these roadways should be breakaway where there is a possibility of being struck by errant vehicles.

On roadways where pedestrian facilities exist, the designer should review the volume of pedestrian traffic to determine if a breakaway support will present a greater potential hazard to the pedestrian traffic than a non-breakaway support will to the vehicular traffic. Examples of locations where the hazard potential to pedestrian traffic would be greater include:

- transportation terminals,
- sports stadiums and associated parking areas,
- tourist attractions,
- school zones, or
- central business districts and local residential neighborhoods where the posted speed limit is 30 mph or less.

In these locations, non-breakaway supports will be used. Other locations which require the use of non-breakaway bases, regardless of the pedestrian traffic volume, are rest areas and weigh station parking lots and combined light and traffic signal poles.

38-5 ROADSIDE BARRIERS

38-5.01 **Types**

The *Illinois Highway Standards* present the details on the roadside barrier types used by the Department. The following sections briefly describe each system and its typical usage. Also, any items used on a case-by-case basis must comply with the appropriate NCHRP 350 criteria.

Generally, the devices listed in this section meet Test Level 3 under the NCHRP 350 criteria. When the design speed is 45 mph (70 km/hr) or less, the designer may consider specifications for devices accepted at Test Level 2. Contact the BDE for further information.

38-5.01(a) Steel Plate Beam Guardrail

The steel plate beam guardrail, commonly known as the "W"-beam system, with strong posts is a semi-rigid system. In general, this guardrail system is the preferred selection on non-freeways and on rural freeways. A major objective of the strong post system is to prevent a vehicle from "snagging" on the posts. This is achieved by using blockouts to offset the posts from the longitudinal beam and by establishing 6'-3" (1905 mm) as the maximum allowable post spacing.

The Department has developed several variations of the steel plate beam guardrail for various applications:

- 1. <u>Type A</u>. The Type A guardrail uses the typical 6'-3" (1905 mm) post spacing, and it is the most commonly used barrier system in Illinois. Type A has a deflection distance of 3 ft (920 mm).
- 2. <u>Type B</u>. The Type B guardrail uses a post spacing of 3'-1½" (953 mm) and has a deflection distance of 2 ft (600 mm). It is used where the deflection distance for the Type A system is unavailable.
- 3. Type C. The Type C guardrail is a single rail that is attached directly to rigid objects where vehicular impacts are not expected and where it is necessary or desirable to carry the guardrail across the face of a structure. Limited applications of this Type are expected (e.g., attachment to a building outside the clear zone where the guardrail is used as a delineation element rather than a roadside barrier). Normally, guardrail will be attached to concrete structures (e.g., piers) in a manner similar to that described in Section 38-6.06(c) for attachments at bridges.
- 4. <u>Type D.</u> See Section 38-7.02 for the use of this Type. It is a double-faced guardrail system used as a median barrier.

 Attached to Headwalls. The Department has developed an adaptation of the steel plate beam guardrail specifically for attachment to concrete headwalls near the edge of shoulder.

38-5.01(b) Concrete Barrier

The concrete barrier should be considered on the roadside to shield rigid objects where no deflection distance is available, where many hits are anticipated, and/or where there is a high volume of heavy trucks (see Section 38-5.02). The concrete barrier is typically used on urban freeways wherever a roadside barrier is warranted. If a rigid object is not continuous (e.g., bridge piers), the designer may use a half-section concrete barrier. To provide the necessary lateral support, provide backfill behind the half-section, or the concrete barrier should have a special footing design (e.g., tied to a concrete surface with reinforcing steel). If this is not practical, use the full-section concrete barrier.

Depending upon site conditions, the height of the concrete barrier may be either 32 in (815 mm) or 42 in (1070 mm). The higher height is more likely to contain and redirect heavy vehicles.

38-5.01(c) Cable Road Guard

Cable road guard is only used where the designer needs to inhibit unwanted vehicular encroachments. It should not be used as a roadside barrier.

38-5.01(d) Other Systems

Many other roadside barrier systems are available which may have application at specific sites (e.g., the thrie beam). The designer should reference the AASHTO *Roadside Design Guide* for information on these systems. The Bureau of Design and Environment must approve the use of any system not included in the *Illinois Highway Standards*.

38-5.02 Barrier Selection

The barrier performance-level requirements must be considered when selecting an appropriate roadside barrier. Traditionally, most roadside barriers have been developed and tested for passenger cars and offer marginal protection when struck by heavier vehicles at high speeds and at other than flat angles of impact. Therefore, if passenger vehicles are the primary concern, the steel plate beam system will normally be selected. However, locations with high traffic volumes, high speeds, high-crash experience, and/or a significant volume of heavy trucks and buses may warrant a higher performance level barrier (e.g., the concrete barrier). This is especially important if barrier penetration by a vehicle is likely to have serious consequences.

The dynamic deflection must also be considered in barrier selection. Figure 38-6H provides the deflection distances for the various systems. If the deflection distance is not obtainable, a concrete barrier should be used.

Another consideration in selecting the barrier type depends on maintenance of the system. Although the steel plate beam guardrail can often sustain second hits, it will need to be repaired with some frequency. In areas of restricted geometry, high speeds, high traffic volumes, and/or where railing repair creates hazardous conditions for both the repair crew and for motorists using the roadway, a rigid barrier should be considered. The concrete barrier also allows better control of roadside vegetation, and it provides a more convenient means to transition into bridge piers. For these reasons, the concrete barrier is typically used on urban freeways where a barrier is required.

Figure 38-5A summarizes the advantages and disadvantages of the roadside barriers used by IDOT and provides their typical usage. Figure 38-5B summarizes the general selection criteria which apply to a roadside barrier.

SYSTEM	ADVANTAGES	DISADVANTAGES	TYPICAL USAGE	
Steel Plate Beam Guardrail	 Lower initial cost. High level of familiarity by maintenance personnel. Can safely accommodate wide range of impact conditions for passenger vehicles. Relatively easy installation. Remains functional after moderate collisions. 	 Cannot accommodate impacts by large vehicles at other than flat angles of impact. At high-impact locations, will require frequent maintenance. Susceptible to vehicular underride and override. Susceptible to vehicular snagging (without rub rail). 	Non-freeways. Rural freeways.	
Concrete Barrier	 Can accommodate most vehicular impacts without penetration. Little or no deflection distance required behind barrier. Little or no damage sustained for most vehicular impacts; therefore, least need for maintenance. No vehicular underride/override potential or snagging potential. 	 Higher initial cost. Can induce vehicular rollover. For given impact conditions, highest occupant decelerations; therefore, least forgiving of barrier systems. Reduced performance where offset between traveled way and barrier exceeds 12 ft (3.6 m). 	 Urban freeways. Where high traffic volumes are present. Where high volumes of large vehicles are present. Where poor geometrics exist. Where snagging is a concern. 	

ROADSIDE BARRIER SELECTION

Figure 38-5A

CRITERIA	COMMENTS
Performance Capability	Barrier must be structurally able to contain and redirect design vehicle.
2. Deflection	Expected deflection of barrier should not exceed available room to deflect.
3. Site Conditions	Slope approaching on the barrier, and distance from traveled way, may preclude use of some barrier types.
4. Compatibility	Barrier must be compatible with planned terminal treatment and capable of transition to other barrier systems (such as bridge railing).
5. Cost	Standard barrier systems are relatively consistent in cost, but high-performance railings can cost significantly more.
6. Maintenance	
a. Routine	Few systems require a significant amount of routine maintenance.
b. Collision	Generally, flexible or semi-rigid systems require significantly more maintenance after a collision than rigid or high-performance railings.
c. Materials Storage	The fewer the number of different systems used, the fewer inventory items/storage space required.
d. Simplicity	Simpler designs, in addition to costing less, are more likely to be reconstructed properly by field personnel.
7. Aesthetics	Occasionally, barrier aesthetics is an important consideration in selection.
8. Field Experience	The performance and maintenance requirements of existing systems should be monitored to identify problems that could be lessened or eliminated by using a different barrier type.

SELECTION CRITERIA FOR ROADSIDE BARRIERS

Figure 38-5B

38-6 ROADSIDE BARRIER LAYOUT

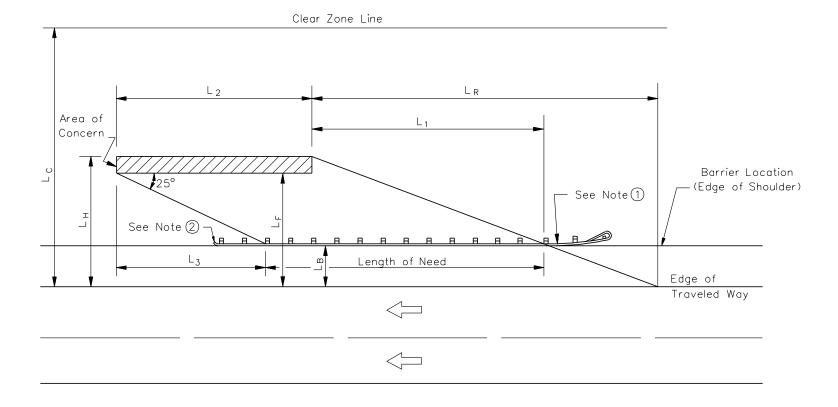
38-6.01 Length of Need

A roadside barrier must be extended a sufficient distance upstream and/or downstream from the hazard to safely protect a run-off-the-road vehicle. Otherwise, the vehicle could travel behind the barrier and impact the hazard. The designer should recognize that vehicles depart the road at relatively flat angles. Based on a number of field studies, the average angle of departure is estimated to be 10°. The 80th percentile is estimated to be 15°. These flat angles of departure result in the need to extend the barrier a significant distance in front of the hazard.

Many factors combine to determine the appropriate length of need for a given roadside condition. These include:

- the distance to the outside limit of the hazard (L_H) or the clear zone (L_C), whichever is less;
- the distance between the edge of traveled way and the barrier (L_B);
- the runout length (L_R), which is based on the design speed (V) and the traffic volume on the facility;
- the length of hazard (L₂), as measured parallel to the roadway;
- whether or not the barrier is on a flare (see Figure 38-6L); and
- on two-way facilities, whether or not the barrier needs to be extended to provide protection for the traffic in the opposing direction.

Figure 38-6A and 38-6B illustrate the variables that will determine the barrier length of need. Figure 38-6A applies to a roadway with traffic moving in one direction or to a two-way roadway where the hazard is not within the clear zone of the opposing direction of travel. Figure 38-6B applies to a two-way facility where the roadside hazard is within the clear zone of the opposing direction of traffic.



Notes:

- ① Use appropriate crashworthy terminal. See Section 38-6.06.
- ② Use acceptable anchorage terminal. See Section 38-6.06.

_B = Distance to barrier

_c = Clear zone

L_H = Distance to back of hazard

L_F = Distance to front of hazard

L_R = Runout length (see Figure 38-6C)

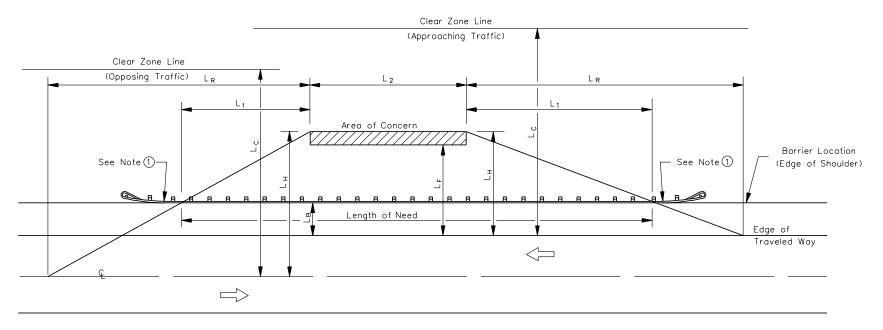
 L_1 = Length needed for approach end

 L_2 = Length of hazard

L₃ = Length to be omitted from length of need

BARRIER LENGTH OF NEED LAYOUT (One-Way Roadways)

Figure 38-6A



Note:

- Use appropriate crashworthy terminal. See Section 38-6.06.
- Use acceptable anchorage terminal. See Section 38-6.06.

= Distance to barrier

= Clear zone

= Distance to back of hazard

= Distance to front of hazard

 L_R = Runout length (see Figure 38-6C)

= Length needed for approach end

 L_2 = Length of hazard

BARRIER LENGTH OF NEED LAYOUT (Two-Way Roadways)

Figure 38-6B

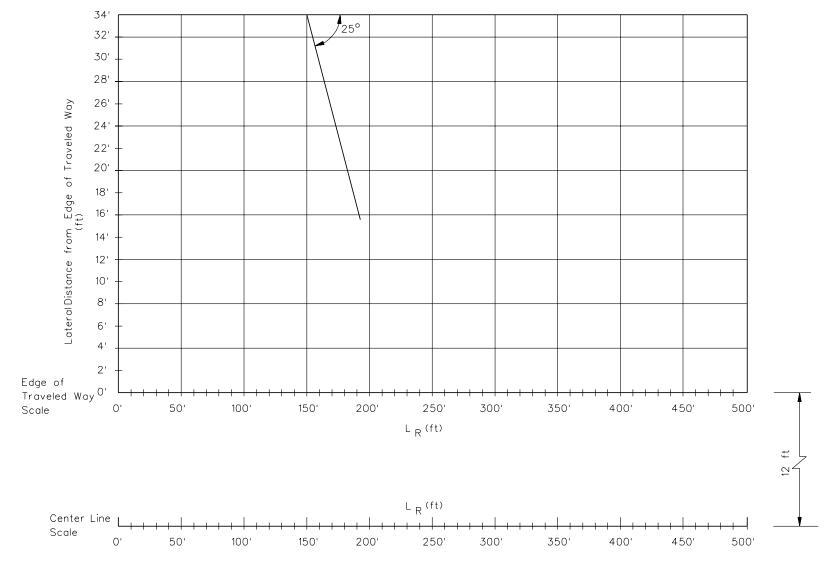
To determine the length of need, use the nomograph in Figure 38-6D and the following procedure:

- Construct a horizontal line at L_B on the y-axis (the lateral distance of the barrier from the edge of traveled way). This assumes that the barrier is not flared; i.e., it is parallel to the roadway.
- 2. Locate L_H or L_C , whichever is less, on the y-axis.
- 3. Determine L_R from Figure 38-6C and locate L_R on the x-axis. If barrier protection is needed for only the approaching traffic, only use the scale marked "Edge of Traveled Way Scale." If needed for both directions of travel, locate L_R on both scales marked "Edge of Traveled Way Scale" and "Centerline Scale." See Step #7 to determine the downstream end of the barrier where the hazard does not require shielding for the opposing traffic.
- 4. Connect the points in Step #s 2 and 3 with a straight line or two straight lines.
- 5. Locate the intersection(s) of the lines in Step #s 1 and 4. From this point(s), draw a line vertically to the L_R Scale(s).
- 6. Read L_1 from the L_R Scale(s). As illustrated on Figures 38-6A and 38-6B, L_1 is measured from the lateral edge of hazard to the beginning of the end terminal; i.e., it does not include the terminal.

		Traffic Volume (ADT)*							
Design Speed		Over	6000	2000-6000		800-2000		Under 800	
		Runout	Length	Runou	t Length	Runou	t Length	Runout	t Length
		L	·R		L_R	I	-R	L	-R
mph	(km/h)	ft	(m)	ft	(m)	ft	(m)	ft	(m)
70	(110)	475	(145)	445	(135)	395	(120)	360	(110)
60	(100)	425	(130)	400	(120)	345	(105)	330	(100)
55	(90)	360	(110)	345	(105)	315	(95)	280	(85)
50	(80)	330	(100)	300	(90)	260	(80)	245	(75)
45	(70)	260	(80)	245	(75)	215	(65)	200	(60)
40	(60)	230	(70)	200	(60)	180	(55)	165	(50)
30	(50)	165	(50)	165	(50)	150	(45)	130	(40)

^{*}Based on a 10 year projection from the anticipated date of construction.

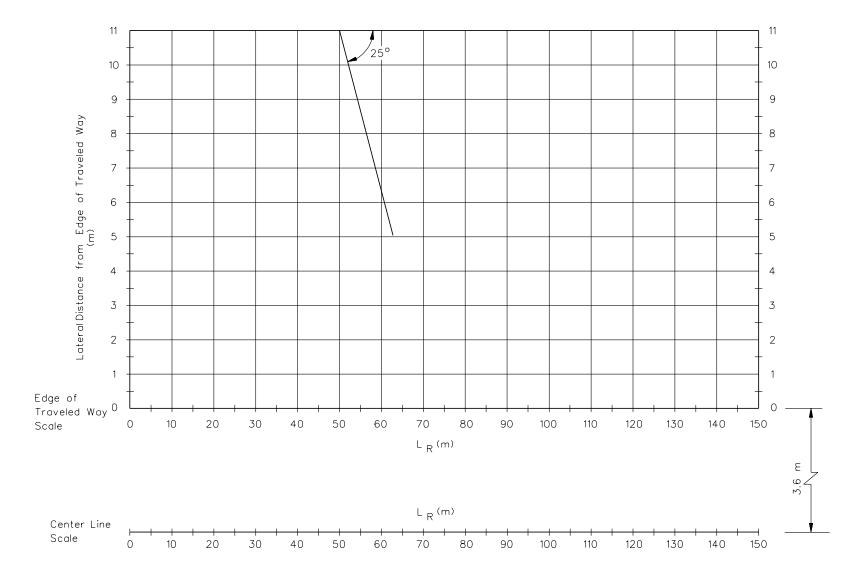
RUNOUT LENGTHS FOR BARRIER DESIGN



Note: Centerline scale assumes a 12-ft lane width. For other lane widths, appropriate adjustments must be made.

BARRIER LENGTH OF NEED CALCULATION (US Customary)

Figure 38-6D



Note: Centerline scale assumes a 3.6-m lane width. For other lane widths, appropriate adjustments must be made.

BARRIER LENGTH OF NEED CALCULATION (Metric)

Figure 38-6D

- 7. If barrier protection is only warranted for one direction of travel (Figure 38-6A), use the following procedure to determine the downstream end of the length of need:
 - a. Locate the distance (L_F) from the front of the hazard to the edge of traveled way on the y-axis.
 - b. From this point, draw a line parallel to the 25° line in Figure 38-6D until it intersects the L_B line (Step #1).
 - c. Move down vertically to the L_R "Edge of Traveled Way Scale" and read L₃.
 - d. As illustrated on Figure 38-6A, the L₃ distance is omitted from the length of need.
- 8. A barrier flare may be used to reduce the barrier length of need. Example 38-6.01(3) illustrates how to use Figure 38-6D to determine L_1 when the barrier is flared.
- 9. The length of need determined in the above steps must be adjusted to provide full 12'-6" (3.81 m) panels of guardrail. The length of guardrail required in advance of the hazard as determined in Step #s 1 through 6 is always rounded up. The length to be omitted as determined in Step #7 is always rounded down.

* * * * * * * * *

Example 38-6.01(1) (One-Way Traffic)

Given: Design ADT = 7000

V = 70 mph

Slope = 1V:6H front slope

Tangent roadway

Shoulder width = $10 \text{ ft} = L_B$

 $L_{H} = 25 \text{ ft}$

One-way roadway

 $L_{\rm F} = 15 \, {\rm ft}$

Unflared barrier (steel plate beam guardrail, Type A) located at edge of shoulder

Problem: Determine the barrier length of need.

Solution: Using the procedure in Section 38-6.01, the following steps apply (see solution in

Figure 38-6E):

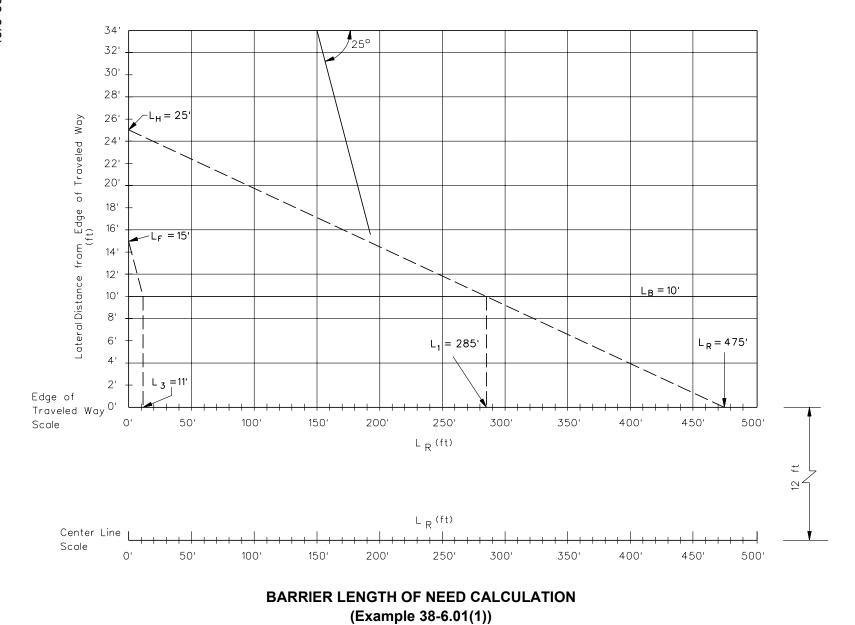


Figure 38-6E

- 1. $L_B = 10$ ft. Figure 38-6E illustrates the horizontal line.
- 2. From Figure 38-3A, L_C = 30 ft to 34 ft (use 30 ft per note). Therefore, because $L_H < L_C$, locate L_H = 25 ft on the y-axis.
- 3. From Figure 38-6C, L_R = 475 ft. Locate point on "Edge of Traveled Way Scale."
- 4. Connect the points in Step #s 2 and 3.
- 5. Draw the vertical line down to the L_R scale.
- 6. Read $L_1 = 285$ ft.
- 7. Use the procedure to locate the downstream end of the barrier length of need:
 - a. Locate $L_F = 15$ ft on the y-axis.
 - b. Draw a line parallel to the 25° line (see Figure 38-6E).
 - c. Draw a vertical line down to the L_R scale. Read L_3 = 11 ft.
- 8. Not applicable (i.e., no flare).
- 9. Round L_1 and L_3 as discussed to ensure only full-length panels of guardrail are used.

Example 38-6.01(2) (Two-Way Traffic)

Given: Design ADT = 5000

V = 60 mph

Slope = 1V:4H front slope

Tangent roadway

Shoulder width = $8 \text{ ft} = L_B$

 $L_{H} = 15 \text{ ft}$

Two-way roadway

 $L_{F} = 10 \text{ ft}$

Unflared barrier (use steel plate beam guardrail, Type B, due to lack of deflection

distance) located at edge of shoulder

Problem: Determine the barrier length of need.

Solution: Using the procedure in Section 38-6.01, the following steps apply (see solution in

Figure 38-6F):

- 1. $L_B = 8$ ft. Figure 38-6F illustrates the horizontal line.
- 2. From Figure 38-3A, L_C = 32 ft to 40 ft (use 30 ft per note). Therefore, because L_H < L_C , locate L_H = 15 ft on the y-axis.
- 3. From Figure 38-6C, L_R = 400 ft. Locate point on "Edge of Traveled Way Scale" and "Center Line Scale."

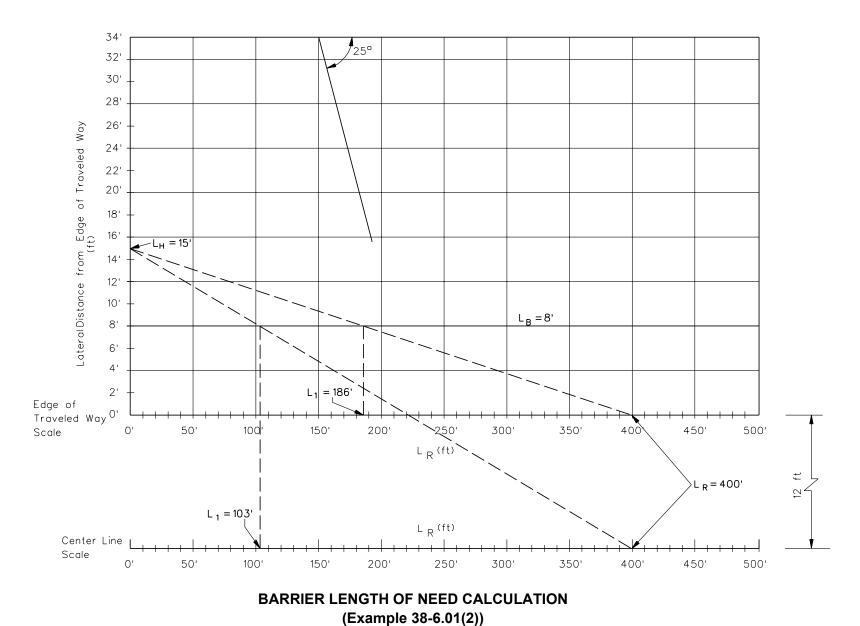


Figure 38-6F

- 4. Connect the points in Step #s 2 and 3.
- 5. Draw the vertical line down to the L_R scales.
- 6. Read L_1 = 186 ft upstream from the hazard and L_1 = 103 ft downstream from the hazard.
- 7. Not applicable.
- 8. Not applicable (i.e., no flare).
- 9. Round L₁ upstream and downstream as discussed to ensure only full-length panels of guardrail are used.

Example 38-6.01(3) (Flared Barrier)

Given: Design ADT = 7000

V = 70 mph

Slope = 1V:6H front slope

Tangent roadway

Shoulder width = $10 \text{ ft} = L_B$

 $L_{H} = 25 \text{ ft}$

One-way roadway

 $L_{\rm F} = 15 \, {\rm ft}$

Barrier (steel plate beam guardrail, Type A) with 1:20 flare

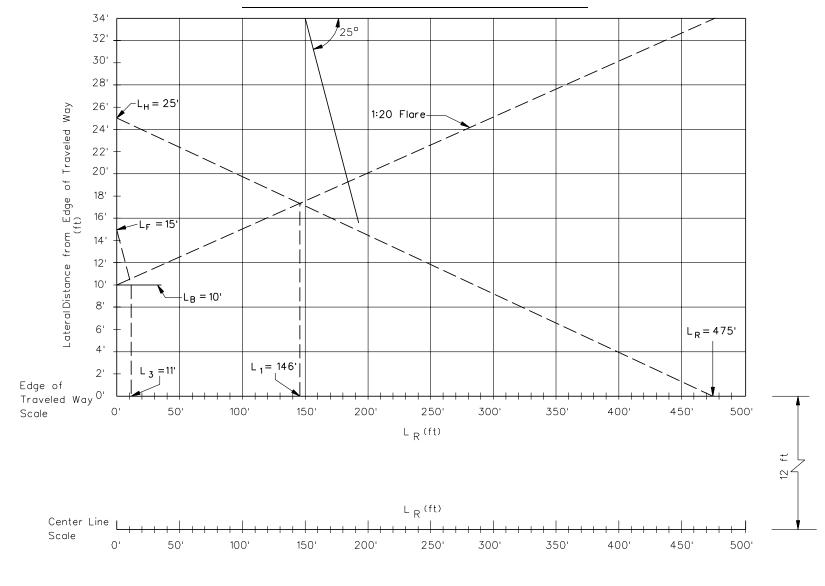
Problem: Determine the barrier length of need.

Solution: Using the procedure in Section 38-6.01 (adjusted for flare), the following steps

apply (see solution in Figure 38-6G):

- 1. Figure 38-6G illustrates the location of barrier with 1:20 flare.
- 2. From Figure 38-3A, L_C = 30 ft to 34 ft (use 30 ft per note). Therefore, because L_H < L_C , locate L_H = 25 ft on the y-axis.
- 3. From Figure 38-6C, L_R = 475 ft. Locate point on "Edge of Traveled Way Scale."
- 4. Connect the points in Step #s 2 and 3.
- 5. Draw the vertical line down to the L_R scale.
- 6. Read L_1 = 146 ft. Note that, for the unflared barrier in Example 38-6.01(1), L_1 = 285 ft.
- 7. Use the procedure to locate the downstream end of the barrier length of need:
 - a. Locate $L_F = 15$ ft on the x-axis.
 - b. Draw a line parallel to the 25° line (see Figure 38-6G).
 - c. Draw a vertical line down to the L_R scale. Read L_3 = 11 ft.
- 8. Flare rate has been used.
- 9. Round L_1 and L_3 as discussed to ensure only full-length panels of guardrail are used.

* * * * * * * * *



BARRIER LENGTH OF NEED CALCULATION (Example 38-6.01(3))

Figure 38-6G

38-6.02 <u>Lateral Placement</u>

Roadside barriers should be placed as far as practical from the edge of traveled way. Such placement provides an errant motorist the best chance of regaining control of the vehicle without impacting the barrier. It also provides better sight distance, particularly at nearby intersections. The following factors should be considered when determining barrier lateral placement:

- 1. <u>Shoulder</u>. Typically, the roadside barrier is located at the edge of the shoulder such that the face of the barrier is flush with the shoulder hinge point.
- <u>Deflection</u>. The dynamic deflection distance of the barrier, as measured from the back of the post, should not be violated. Figure 38-6H provides the deflection distances for the types of roadside barriers typically used by IDOT.

Barrier Type	Deflection Distance
Type A Steel Plate Beam Guardrail @ 6'-3" (1905 mm) post spacing	3 ft (920 mm)
Type B Steel Plate Beam Guardrail @ 3'-11/2" (953 mm) post spacing	2 ft (600 mm)
Concrete Barrier	0.0 ft (0.0 mm)

DYNAMIC DEFLECTION OF BARRIERS Figure 38-6H

3. <u>Shy Distance</u>. Drivers tend to "shy" away from continuous longitudinal obstacles along the roadside, such as guardrail. Therefore, the lateral barrier offset should desirably be based on the criteria in Figure 38-61.

US Cu	stomary	Metric		
Design Speed	Shy Line Offset	Design Speed	Shy Line Offset	
(mph)	(ft)	(km/h)	(m)	
70	9.2	120	3.2	
65	8.6	110	2.8	
60	7.9	100	2.4	
55	7.2	90	2.2	
50	6.6	80	2.0	
45	5.6	70	1.7	
40	4.6	60	1.4	
35	4.1	50	1.1	
30	3.6			

SUGGESTED SHY LINE OFFSET Figure 38-6I

- 4. <u>Steep Slopes</u>. Where a barrier is placed on steep slopes, it may be necessary to provide a minimum 2 ft (600 mm) width behind the guardrail for additional post support, to reduce erosion, and to lessen maintenance needs.
- 5. <u>Shoulder Stabilization</u>. Where a barrier is placed on high fills or highly erodible soils, it may be desirable to provide shoulder stabilization in accordance with the *Illinois Highway Standards*. The District Geotechnical Engineer should be consulted for quidance.

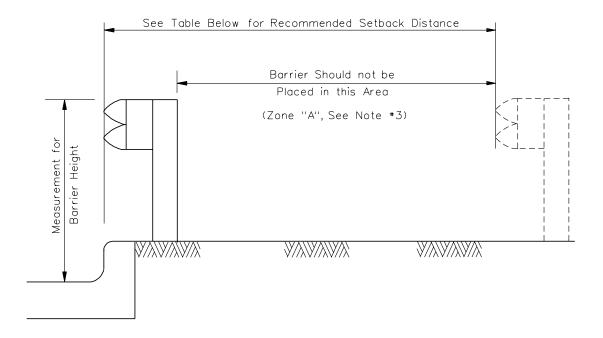
38-6.03 Placement Behind Curbs

If practical, roadside barriers should not be placed in conjunction with either sloping or vertical curbs. Where this is necessary, the following will apply (see Figure 38-6J):

- 1. Roadside Barrier/Curb Orientation. Ideally, the face of the barrier should be in line with the face of the curb (i.e., at the gutter line). However, this is not always practical. At a maximum, the barrier face should be no more than 1 ft (300 mm) from the face of curb. The height of the guardrail must be measured from the pavement or paved shoulder surface. In addition, the designer should consider reducing the curb height to 4 in (100 mm) and stiffening the rail to reduce vaulting potential. Rail stiffening may be accomplished by using Type B guardrail, by using a double nested Type A rail, or by bolting a W-beam to the back of the posts.
- Lateral Placement. The table in Figure 38-6J presents criteria to determine proper barrier placement behind curbs. If a barrier must be located in the zone not recommended, the designer must use the M2 (M5) sloping curb. The 2 in (50 mm) height will introduce little or no vehicular vaulting and, therefore, will not interfere with the proper vehicular/barrier interaction. The M2 (M5) curb will extend upstream from the end of the roadside barrier by a distance determined as indicated in Figure 38-6K.

38-6.04 Placement on Slopes

Slopes in front of a barrier should be 1V:10H or flatter. This also applies to the areas in front of the flared section of guardrail and to the area approaching the terminal ends.



US Cus	stomary	Metric		
Design Speed	Design Speed Curb-to-Barrier		Curb-to-Barrier	
(mph)	Distance* (ft)	(km/h)	Distance* (m)	
≤ 30	NA	≤ 50	NA	
35 – 40	8	60	2.5	
45	10	70	3.0	
≥ 50	See Note (1)	≥ 80	See Note (1)	

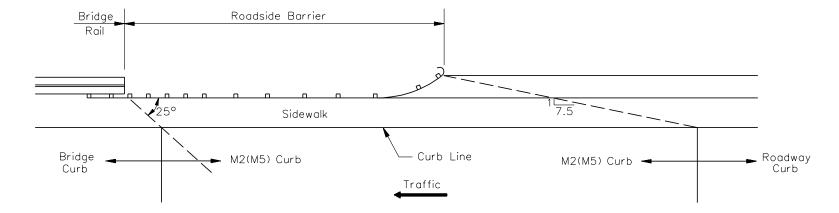
^{*}Values in table represent distance beyond which it is acceptable to place a barrier.

Notes: 1. For design speeds ≥ 50 mph (80 km/h), curbs should not be used with a barrier.

- 2. Barrier should be flush with curb as shown. At a maximum, the barrier face may be placed up to 1 ft (300 mm) behind curb. When placed behind the face of the curb, reductions in curb height and rail stiffening should be considered.
- 3. If barrier must be placed in Zone A above, use the M2 (M5) curb. See Figure 38-6K.

PLACEMENT OF BARRIER RELATIVE TO CURBS

Figure 38-6J



USE OF ROADSIDE BARRIER WITH M2 (M5) CURB Figure 38-6K

38-6.05 Barrier Flare

Flaring a roadside barrier away from the roadway has two benefits:

- the necessary length of need is reduced, and
- the barrier is less likely to be impacted.

The disadvantage is that a flare will increase the vehicular angle of impact. Figure 38-6L presents suggested flare rates for roadside barriers which are intended to balance the advantages and disadvantages of flares.

Design Speed		Flare Rate for Barrier	Flare Rate for Barrier Beyond Shy Line*		
(mph)	(km/h)	Inside Shy Line*	Rigid (Concrete)	Semi-Rigid (GR)	
70	110 – 120	1:30	1:20	1:15	
60	100	1:26	1:18	1:14	
55	90	1:24	1:16	1:12	
50	80	1:21	1:14	1:11	
45	70	1:18	1:12	1:10	
40	60	1:16	1:10	1:8	
30	50	1:13	1:8	1:7	

^{*}See Figure 38-6I for shy line distances.

SUGGESTED FLARE RATES FOR BARRIER DESIGN

Figure 38-6L

38-6.06 <u>Terminal Treatments</u>

Barrier terminal sections present a potential roadside hazard for run-off-the-road vehicles; however, they are also critical to the proper structural performance of the barrier system. Therefore, the designer must carefully consider the selection and placement of the terminal end.

The *Illinois Highway Standards* present the design details for several end treatments used by the Department. Other proprietary terminal treatments are allowed under various Specifications and Special Provisions. The particular proprietary items routinely allowed for use on IDOT projects are included in the Department's "Special Notice" that is included periodically in the Notice of Letting. The following sections briefly describe each system and, where applicable, discuss typical uses of the system.

The various end treatments may allow a portion of the terminal to be included in the length of need. The designer should include any applicable portion when determining the location of the terminal.

38-6.06(a) Guardrail Ends

The following terminals are applicable to the steel plate beam guardrail:

- 1. Type 1, Special (Flared). This terminal section is intended for use with steel plate beam guardrail. All approved terminals meet NCHRP 350 criteria. The designer should choose a flared terminal where practical, if no additional right-of-way must be purchased for installation. Specifications require that all Type 1 Special (Flared) terminals provide 37.5 ft (11.4 m) length of need. The leading portion of the terminal is normally a gating design and not included in the length of need. Because of the gating function, the area behind and beyond the terminal should be relatively free of significant fixed objects. The minimum recommended distance is a rectangular area approximately 75 ft (23 m) beyond the terminal parallel to the rail and 20 ft (6 m) behind and perpendicular to the rail.
- 2. Type 1, Special (Tangent). This is a terminal section intended for use with steel plate beam guardrail. All approved terminals meet NCHRP 350 criteria. Tangent terminals should be chosen in areas where the cross section or drainage structure would require additional right-of-way to accommodate the Type 1 Special (Flared) terminal. Specifications require that all Type 1 Special (Tangent) terminals provide 37.5 ft (11.4 m) length of need. The leading portion of the terminal is normally a gating design and not included in the length of need. Because of the gating function, the area behind and beyond the terminal should be relatively free of significant fixed objects. The minimum recommended distance is a rectangular area approximately 75 ft (23 m) beyond the terminal parallel to the rail and 20 ft (6 m) behind and perpendicular to the rail.
- 3. <u>Type 1B</u>. This terminal should be used at the approaching or departing (where practical) end of roadside barriers where appropriate cut or artificial mound conditions exist or can reasonably be constructed.
- 4. <u>Type 2</u>. This is an unflared terminal with a cable anchor. The Type 2 should be used on the departing end of steel plate beam guardrail where end-on impacts are not a consideration; i.e., on one-way roadways. The length of this terminal should not be considered as part of the length of need required to shield the hazard.

38-6.06(b) Median Barriers

See Section 38-7.04(d) for guidance on Department-approved end terminals for median barriers (Traffic Barrier Terminal, Type 3 (Special)). These also apply to the ends of the concrete barrier where it is used as a roadside barrier.

38-6.06(c) Bridge Rail Connections

Roadside barriers are often terminated with a transition into a bridge rail. The following terminals are used as bridge rail connections:

- Type 5. This is a connector terminal which should be used to connect steel plate beam guardrail to the concrete bridge parapet or end post at the departing end of a new oneway bridge.
- Type 5A. This is a connector terminal that should only be used for repair of existing installations on the State system, and for Local Roads projects, if specified by the Local Agency. It is used to connect steel plate beam guardrail to a steel bridge rail at either the approaching end or departing end of the bridge. For applications on the State highway system, or other locations where compliance with NCHRP 350 is required, see Type 6.
- 3. Type 6. Recent modifications to the design of this terminal have achieved compliance with NCHRP 350. This is a connector terminal that includes a transition section, special posts, blockouts, and end shoe. It also requires the use of a curb. Use Type 6 to attach steel plate beam guardrail to the end(s) of bridges with concrete parapet or to a permanent concrete barrier. It may also be used to connect the steel plate beam guardrail to the face of the other concrete structures where the related curb can be installed.
- 4. <u>Type 6A</u>. This transition is similar to the Type 6, except it is used for attachment of steel plate beam guardrail to either curb-mounted steel bridge rail or to side-mounted steel bridge rail (two element rail systems approved under NCHRP 350). When used with a bridge rail system that includes a curb, a curb must be used with the Type 6A, similar to the Type 6. If there is no curb used on the bridge, do not use a curb with the Type 6A.
- 5. Type 6B. This transition is used when connecting steel plate beam guardrail to the face of a concrete structure (e.g., a pier) and where the installation of a curb is either not possible or desirable. It requires blocking out the thrie beam rail of the transition by 8 in (200 mm) at the connection point. The designer must carefully weigh the relative merits of this potential loss of horizontal clearance against the complications of adding a curb when selecting between the Type 6B terminal and the Type 6 for attachment to a structure.
- 6. Type 8. This is a connector terminal that includes a transition section, special posts, blockouts, and a turned-down connection to the top of the safety curb. Only use Type 8 to repair existing installations until the bridge cross section can be reconstructed with a bridge railing and guardrail transition system accepted under NCHRP 350 and approved by the Department.

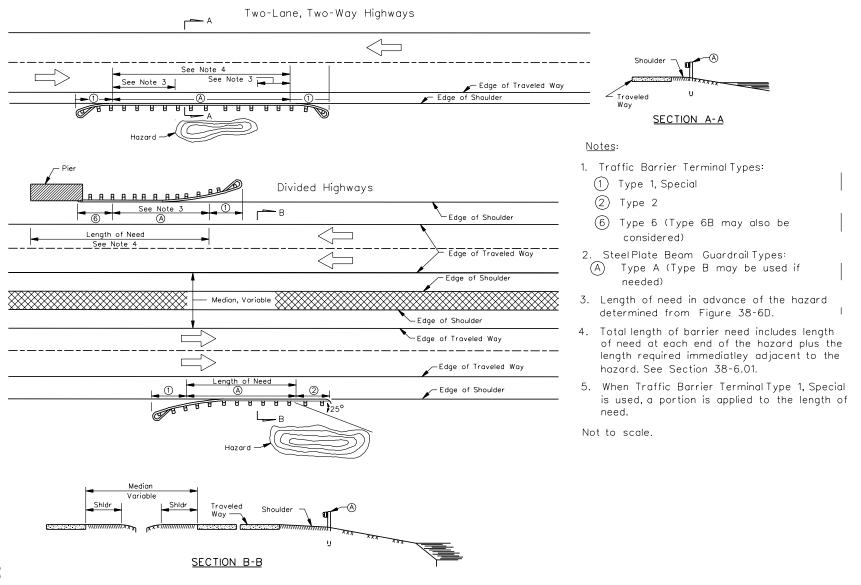
- 7. Type 9. This is a connector terminal to transition from tubular thrie beam retrofit to steel plate beam guardrail. Only use Type 9 to repair existing installations until the bridge cross section can be reconstructed with a bridge railing and guardrail transition system accepted under NCHRP 350 and approved by the Department.
- 8. <u>Type 10</u>. This is a connector terminal that should be used to connect steel plate beam guardrail to the departing end of existing one-way bridges.
- 9. <u>Type 11</u>. This is a connector terminal that should be used to connect temporary bridge railing to temporary concrete barrier. Specifications for the temporary concrete barrier require that the last segment of barrier be fixed in place by anchor pins. These pins are critical to the performance of this terminal to avoid a potential "pocketing" location for impacting vehicles.
- 10. Type 12. This is a terminal used to shield the end post(s) of the bridge and to terminate tubular thrie beam on the departing end of one-way bridges that have the tubular thrie beam retrofit for bridges, and when there is not warranting criteria for additional steel plate beam guardrail off the end of the bridge. Because there is no NCHRP 350 accepted transition from the tubular thrie beam retrofit rail for the approach end, only use Type 12 to repair existing installations until the bridge cross section can be reconstructed with a bridge railing and guardrail transition system accepted under NCHRP 350 and approved by the Department.

38-6.07 Minimum Length/Gaps

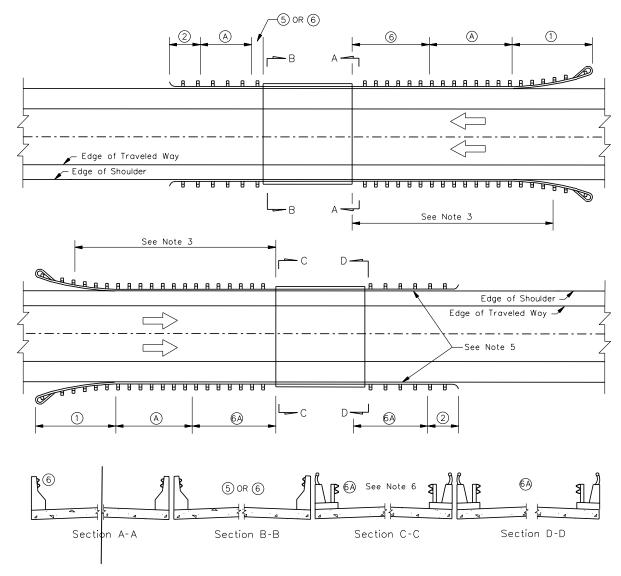
Short runs of barrier have limited value and should be avoided unless designed especially to shield a point hazard. As a rule of thumb, a barrier should have at least 100 ft (30 m) of standard guardrail section exclusive of terminal sections and/or transition sections. Likewise, short gaps between runs of barrier are undesirable. Therefore, gaps of less than 200 ft (60 m) between barrier termini should be connected into a single run. Exceptions may be necessary for access.

38-6.08 Typical Applications

Figures 38-6M through 38-6O illustrate typical applications of roadside barrier installations.



TYPICAL APPLICATION OF GUARDRAIL AND TRAFFIC BARRIER TERMINAL Figure 38-6M



Notes:

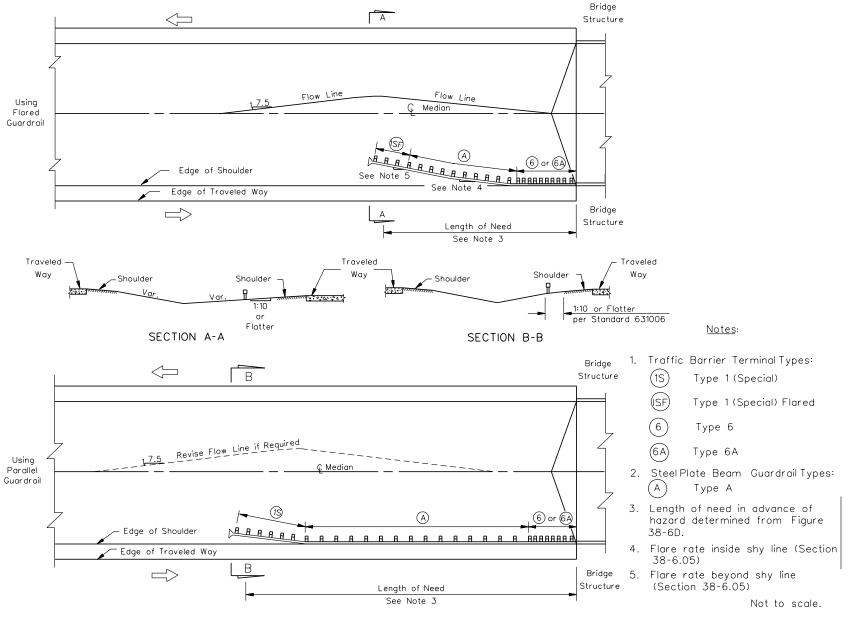
- 1. Traffic Barrier Terminal Types:
 - 1) Type 1, Special
 - (2) Type 2
 - (5) Type 5
 - (6) Type 6
 - (6A) Type 6A
- 2. Steel Plate Beam Guardrail Types:
 - (A) Type A
- 3. Guardrail length of need should be determined from Figure 38-6D.
- 4. When Traffic Barrier Terminal Type 1, Special is used, a portion of terminal is applied to the length of need, determined from Figure 38-6D.
- Guardrail is to be placed at the departing end of one-way bridges only when guardrail is needed for some other uncorrectable hazard. Length of need as per Note 3 above.
- 6. Safety walk greater than 9 in (225 mm) wide must be removed or retrofitted.

Not to scale.

TYPICAL APPLICATION OF GUARDRAIL AND TRAFFIC BARRIER TERMINALS (Median Widths Less Than 64 ft (19.5 m) at Dual Structures)

Figure 38-6N





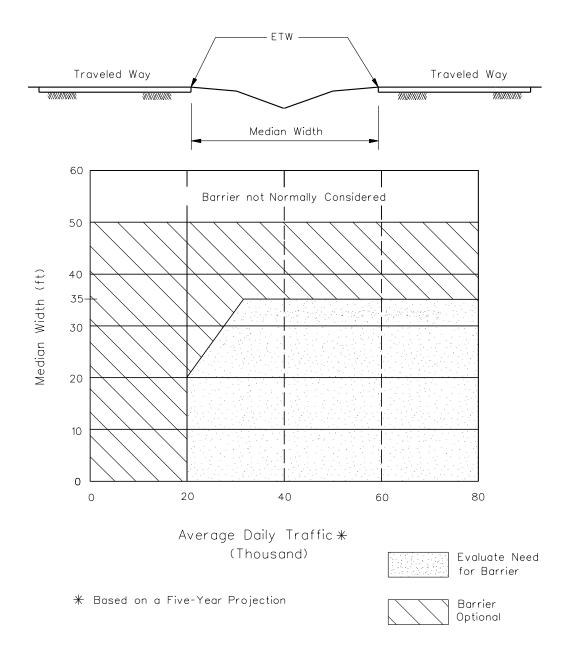
TYPICAL APPLICATION OF GUARDRAIL AND TRAFFIC BARRIER TERMINALS
(For Median Widths at Dual Structures)
Figure 38-60

38-7 MEDIAN BARRIERS

38-7.01 **Warrants**

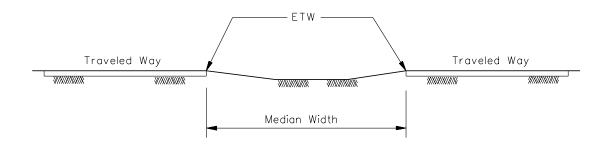
Median barriers prevent errant vehicles from crossing the median of a divided highway and colliding head-on with vehicles in the opposing direction of travel. The following summarizes the Department's criteria:

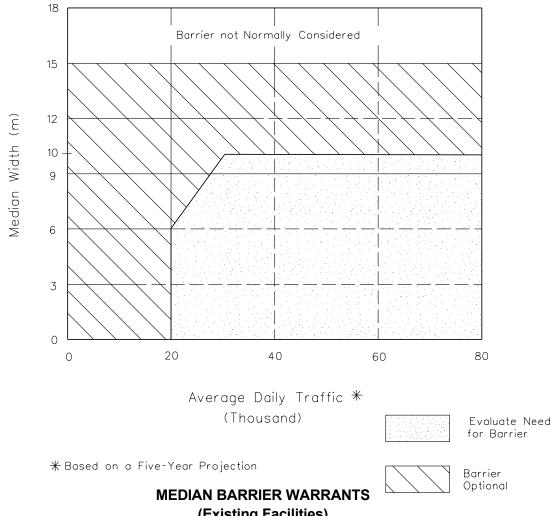
- 1. New Facilities. Median barriers are usually warranted on freeways, expressways, and other multi-lane, high-speed highways where the selected median width does not provide a satisfactory physical impediment to vehicular crossovers. In addition, median barriers are warranted where the median does not provide sufficient lateral space for safe vehicular recovery within the median. On highways with partial access control, the median barrier must terminate at each at-grade intersection, which is undesirable due to sight distance considerations and the need to provide a safety treatment for the end of the barrier.
 - In addition, lower speeds will reduce the likelihood of a crossover accident. Therefore, on non-freeway highways, the designer should evaluate the crash history, traffic volumes, speeds, median width, alignment, sight distance, and construction costs to determine the need for a median barrier.
- Existing Facilities. Figure 38-7A presents the warrants for a median barrier based on median width and traffic volumes. Note that the traffic volumes are based on a 5-year projection. In the areas shown as optional, the decision to use a median barrier will be based on construction and maintenance costs and crossover crash experience. A median barrier may also be warranted on medians not within the optional or warranted areas if a significant number of crossover crash have occurred.



MEDIAN BARRIER WARRANTS (Existing Facilities) (US Customary)

Figure 38-7A





(Existing Facilities)
(Metric)

Figure 38-7A

38-7.02 **Types**

The *Illinois Highway Standards* present the details on the median barrier types used by the Department. The following briefly describes each type:

- 1. <u>Steel Plate Beam Guardrail, Type D</u>. The Type D and double steel plate beam guardrail median barrier with strong posts is a semi-rigid system. Its performance is similar to the steel plate beam guardrail system. This median barrier is most applicable to medians with intermediate width and/or moderate traffic volumes. Another application of the Type D median barrier is for the separation of adjacent on/off ramps at interchanges.
- 2. <u>Concrete Barrier</u>. The concrete barrier is a rigid system with the F-shape face configuration. It will rarely deflect upon impact. A half-section concrete barrier may be necessary where crossover crashes have been an issue on wider medians or where the median barrier must divide to go around a fixed object in the median (e.g., bridge piers). In this situation, the obstacle is typically encased within concrete to create a level surface from barrier face to barrier face.

The standard 32 in (815 mm) concrete barrier, a NCHRP 350 Test Level 4 design, may not successfully redirect heavy vehicles if the impact speed and angle are high. Therefore, on some highways it may be warranted to install a 42 in (1070 mm) or higher wall. The barrier maintains the standard safety shape of the 32 in (815 mm) concrete barrier, but it is extended an additional 10 in (255 mm). Concrete barriers designed to heights of 42 in (1070 mm) or higher are considered NCHRP 350 Test Level 5 designs. However, these taller walls restrict sight distance around horizontal curves and restrict vision for authorized vehicles (e.g., police) who wish to view the opposing lanes.

38-7.03 Median Barrier Selection

IDOT has adopted the following guidelines for the selection of median barrier systems. These involve a subjective evaluation of the many trade-offs between systems:

- Median Width. The median width will significantly affect the probability of impact (i.e., the number of hits) and the likely angles of impact. The former will influence maintenance costs; the latter influences safety. The greater the offset to the barrier, the higher the likely angle of impact. Therefore, considering both maintenance and safety, this favors the use of the concrete barrier on narrow median widths and the Type D for wider medians. The concrete barrier may be used on wider median widths on high-volume roadways where crossover crashes would be catastrophic.
- 2. <u>Traffic Volumes</u>. The higher the traffic volume, the higher the likelihood of an increased number of impacts on the median barrier. From a maintenance perspective, this favors the concrete barrier; from a safety perspective, this favors the Type D system. As a guide, the concrete barrier is likely to be cost effective if, during the peak hour, the Level of Service

for traffic is LOS C or worse (approximately 12,000 vehicles per lane per day or more) and the offset to the concrete barrier from the traveled way is 12 ft (3.6 m) or less.

- 3. <u>Heavy Vehicle Traffic</u>. The concrete barrier is more likely to restrain and redirect heavy vehicles (trucks and buses) than the Type D system. Therefore, where there is a high volume of heavy vehicles, this may favor the concrete barrier even on medians wider than 25 ft (8 m). If there has been an adverse history of heavy-vehicle cross over crashes, the 42 in (1070 mm) concrete barrier should be considered.
- 4. <u>Costs.</u> The initial cost of the concrete barrier will exceed, perhaps by a wide margin, the initial cost of the Type D median barrier. The concrete barrier may also require a closed drainage system in the median, further increasing initial costs. However, the maintenance costs per impact on the concrete barrier will probably be far less, which favors the concrete barrier in narrow medians and/or on high-volume highways.
- Maintenance Operations. Two factors are important. First, maintenance response time will influence safety. The longer a damaged section of median barrier is present, the greater the likelihood of a second impact on a substandard barrier. This observation favors the use of the concrete barrier which normally sustains far less damage when impacted. Second, the maintenance operations for repairing damaged barrier can interrupt traffic operations. It is particularly undesirable to close a traffic lane to repair a barrier. The consideration of maintenance operations generally favors the use of the concrete barrier in narrow medians and/or on high-volume highways.
- 6. <u>Appurtenances</u>. A roadway with a median barrier may also warrant other appurtenances in the median (e.g., highway lighting, signs, glare screens). The concrete barrier is more readily adaptable to accommodating these appurtenances than the Type D median barrier. Therefore, if these appurtenances are warranted, this favors the use of the concrete barrier.

Figure 38-7B summarizes the advantages and disadvantages of the median barriers used by IDOT and provides their typical usage.

The barriers discussed above may also be used in locations other than medians. This would typically occur where a barrier is needed to separate lanes of traffic moving in the same direction, or beginning to diverge.

SYSTEM	ADVANTAGES	DISADVANTAGES	TYPICAL USAGE		
Steel Plate Beam Guardrail, Type D	 Lower initial cost. High level of familiarity by maintenance personnel. Can safely accommodate wide range of impact conditions for passenger vehicles. Relatively easy installation. Remains functional after moderate collisions. 	 Cannot accommodate impacts by large vehicles at other than flat angles of impact. At high-impact locations, will require frequent maintenance. Susceptible to vehicular underride and override. Susceptible to vehicular snagging. 	Wider medians. Low to mid-range of traffic volumes.		
Concrete Barrier	 Can accommodate most vehicular impacts without penetration, especially the 42 in (1070 mm) concrete barrier. Little or no deflection distance required behind barrier. Little or no damage sustained for most vehicular impacts; therefore, least need for maintenance. No vehicular underride/override potential or snagging potential. Light supports, sign supports, glare screens, etc., may be mounted on top. 	 Higher initial cost. Can induce vehicular rollover. For given impact conditions, highest occupant decelerations; therefore, least forgiving of barrier systems. Reduced performance where offset between traveled way and barrier exceeds 12 ft (3.6 m). 	 Urban freeways. Where high traffic volumes are present. Where high volumes of large vehicles are present. Where maintenance operations will require lane closure. 		

MEDIAN BARRIER SELECTION

Figure 38-7B

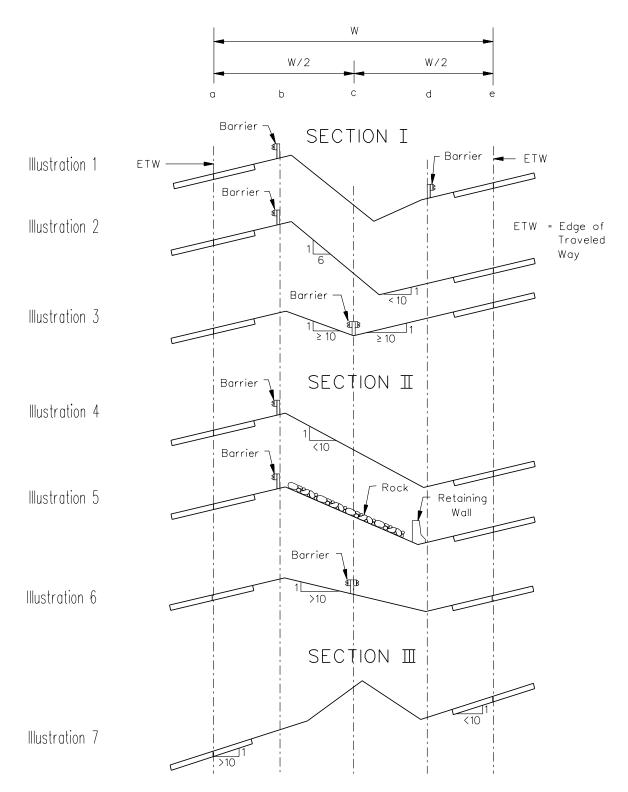
38-7.04 Median Barrier Layout

Much of the information presented in Section 38-6 on roadside barrier layout also applies to median barriers (e.g., placement behind curbs). The following sections present criteria specifically for the design of median barriers.

38-7.04(a) Sloped Medians

A median barrier should not be placed on a slope steeper than 1V:10H. Where the median slopes are steeper than 1V:10H, the designer should provide special consideration to median barrier placement. Figure 38-7C illustrates three basic types of sloped medians. The following discusses barrier placement for each type (assuming a median barrier is warranted):

- 1. For Cross Section I, the designer should determine if the individual slopes warrant protection based on the criteria in Section 38-4. If both slopes warrant protection (Illustration 1), a roadside barrier should be placed at "b" and "d". If only one slope warrants protection, the median barrier should be placed to shield that slope. If neither slope warrants protection and both slopes are steeper than 1V:10H (Illustration 2), a median barrier should be placed at "b" or "d," whichever is shielding the steeper slope. If the slopes are 1V:10H or flatter (Illustration 3), the median barrier should be placed in the center of the median.
- 2. For Cross Section II, the slope in the median will determine the proper treatment. If the slope is steeper than 1V:10H but flatter than 1V:3H (Illustration 4), the median barrier should be placed at "b". If the median slope is 1V:3H or steeper, a roadside barrier at "b" is the only necessary treatment. If the median slope is a roadside hazard (e.g., rough rock cut) (Illustration 5), a roadside barrier should be placed at both "b" and "d". If the median slope is 1V:10H or flatter (Illustration 6), the median barrier should be placed in the center of the median.
- 3. For Cross Section III (Illustration 7), the redirective capacity of the median slope will determine the proper treatment. If the median slope is 1V:3H or steeper and 3 ft (1 m) or higher, no roadside or median barrier is necessary. If the median slopes are flatter than 1V:3H and/or not 3 ft (1 m) high, the median barrier should be placed at the apex of the cross section.



MEDIAN BARRIER PLACEMENT (Sloped Medians)

Figure 38-7C

38-7.04(b) Flared/Divided Median Barriers

It may be necessary to intermittently divide a median barrier or to flare the barrier from one side to the other. A sloped median or a fixed object in the median may require this. The median barrier may be divided by one of these methods:

- 1. A fixed object may be encased by a concrete barrier.
- 2. A half-section concrete barrier may be used on both sides to shield a fixed object.
- 3. Steel Plate Beam Guardrail, Type D median barrier can be split into two separate runs of barrier passing on either side of the median hazard (fixed object or slope). See Figure 38-7D.

If a median barrier is split, the designer should adhere to the suggested flare rates. See Figure 38-6L. Figures 38-7D and 38-7E illustrate median barrier applications around fixed objects.

38-7.04(c) Barrier-Mounted Obstacles

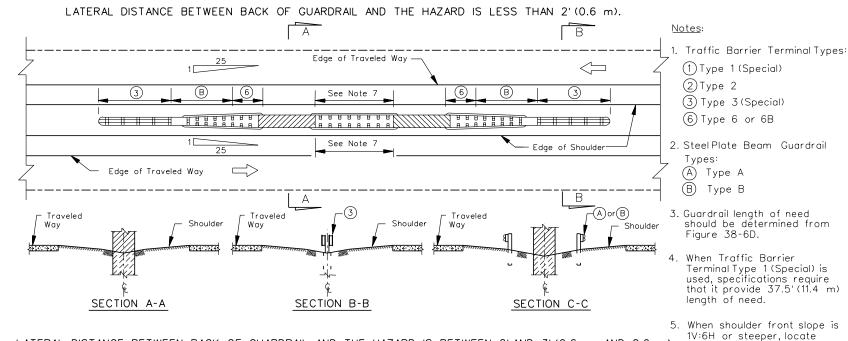
The designer may consider an additional factor when a concrete barrier divides to pass on either side of an obstacle or when obstacles are mounted on top of a concrete barrier (e.g., luminaire supports). If trucks or buses impact the concrete barrier, their high center of gravity may result in a vehicular roll angle which possibly will allow the truck or bus to impact the obstacle on top of the concrete barrier. Two potential countermeasures are to:

- 1. provide a 2 ft (600 mm) deflection distance between the barrier and obstacle (e.g., bridge piers); or
- 2. use the 42 in (1070 mm) concrete barrier.

38-7.04(d) Terminal Treatments

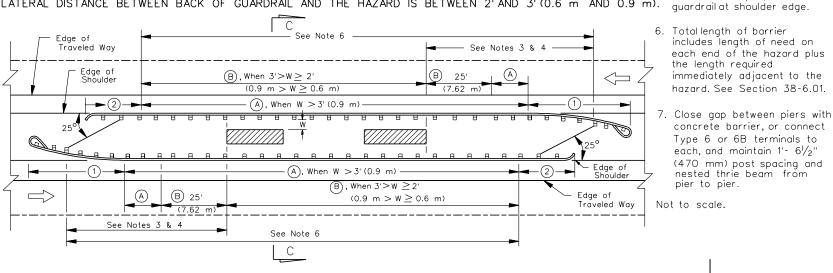
As with roadside barrier terminals, median barrier terminals present a potential roadside hazard for run-off-the-road vehicles. Therefore, the designer must carefully consider the selection and placement of the terminal end. If practical, the median barrier should be extended into a wider median area. See the *Illinois Highway Standards*, Specifications, Special Provisions, and the Department's approved list of NCHRP 350 devices for details and further information. The following terminal treatments are used by IDOT for median barriers:

SAFETY



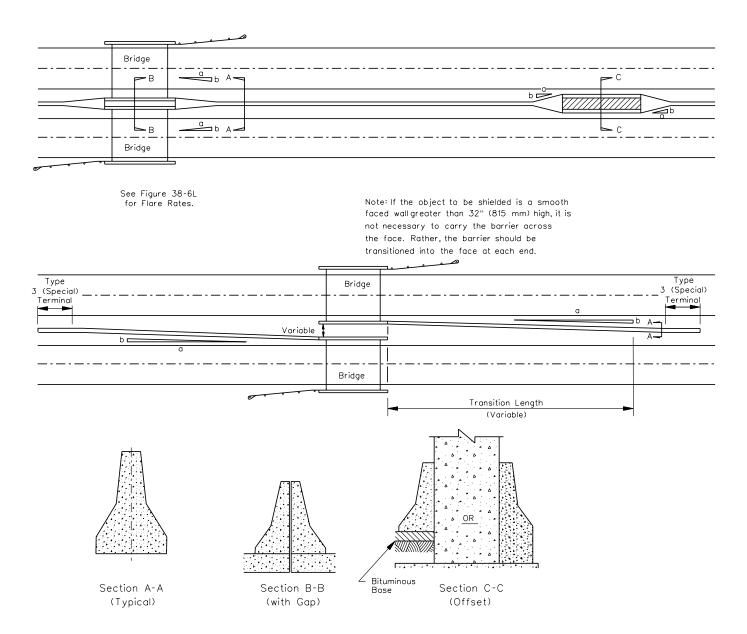
LATERAL DISTANCE BETWEEN BACK OF GUARDRAIL AND THE HAZARD IS BETWEEN 2' AND 3' (0.6 m AND 0.9 m).

38-7(10)



TYPICAL APPLICATION OF STEEL PLATE BEAM MEDIAN BARRIER (Around Fixed Obstacles)

Figure 38-7D



TYPICAL APPLICATION OF CONCRETE BARRIER Figure 38-7E

- 1. <u>Type 3 (Special).</u> These are proprietary end treatments that are accepted under NCHRP 350 and approved by the Department. They may be used as noses for Steel Plate Beam Guardrail, Type D, or Concrete Barrier. The list of approved devices is included in the Notice of Letting as a Special Notice. Not all of these devices may be appropriate for all installations. The designer should add a special provision to the contract if any of the devices should not be used. Contact the BDE for further guidance.
- 2. <u>Type 4.</u> This terminal does not meet the NCHRP 350 criteria and is no longer considered acceptable for use. The designer should provide an appropriate guardrail connector terminal at the bridge, length-of-need guardrail of other type(s), and a compatible guardrail end terminal. Guardrail may be flared according to Figure 38-6L. Special grading plans may be needed to ensure 1V:10H or flatter foreslopes and adequate drainage in the runout area.
- 3. Other. See the Roadside Design Guide for other operational end terminals for median barriers. These may be used on a case-by-case basis. Consult the BDE for more information.

38-7.04(e) Superelevation

Chapter 32 discusses superelevation development for multilane divided facilities. Where a median barrier is present, the axis of rotation is typically about the two median edges. This will allow the median (and the barrier) to remain in a horizontal plane through the curve. See Chapter 32 for more information.

38-7.04(f) Maintenance/Emergency Crossovers

Chapter 44 discusses Department policies on the warrants and design of maintenance and emergency crossovers. If practical, these should be avoided where a median barrier is present. If a crossover must be provided, the barrier should be terminated as described in Section 38-7.04(d). The width of the opening should be approximately 25 ft (7.5 m) to 30 ft (9.0 m). This is wide enough to safely allow a maintenance or emergency vehicle to turn through, but it is narrow enough to minimize the possibility of a run-off-the-road vehicle passing through.

38-7.05 Glare Screens

38-7.05(a) General

Headlight glare may be defined "as a sensation experienced when a person's vision is interrupted by a light source which has a much higher intensity than the surrounding area." It is frequently cited as a major contributing factor in nighttime crashes which occur on unlighted

highways. The magnitude and severity of headlight glare depends on various combinations of a wide variety of factors, including:

- headlight systems, which include the headlight configuration, mounting height, and output intensity;
- roadway features, which include the roadway alignment, geometrics, and pavement reflectivity;
- transmission media, which includes the atmosphere and physical features through which the light must pass, such as windshields and eyeglasses; and
- human variables, which include driver's age, visual ability, and fatigue.

Depending on the severity and effect glare has on a driver, it may be classified as discomfort or disability glare, defined as follows:

- 1. <u>Discomfort</u>. Discomfort glare does not necessarily impair the vision. However, it frequently causes drivers to become tense and apprehensive, which increases the level of fatigue and may lead to driver error. This type of glare is common and usually occurs where median or outer separator widths are greater than approximately 30 ft (10 m).
- 2. <u>Disability</u>. Disability glare definitively impairs a driver's vision, frequently causing temporary blindness; consequently, it should be addressed whenever practical. Disability glare occurs usually where median or outer separator widths are less than approximately 30 ft (10 m) in width, on horizontal curves, and/or where transitions alter the highway alignment.

38-7.05(b) Warrants

As indicated, headlight glare from opposing traffic can be bothersome and distracting. Glare screens can be used with or without median barriers to eliminate the problem and should be used when no other practical alternative exists to eliminate disability glare (e.g., wider median, outer separation, highway lighting, landscaping). The designer should consider if the following conditions exist when determining the need for a glare screen:

- unlighted divided highways where design speeds are 50 mph (80 km/h) or greater and medians 30 ft (9 m) or less in width;
- horizontal curves on divided highways;

- points where the separation between a mainline and frontage road is minimal and alignment is such that mainline traffic is affected by the lights of vehicles using the frontage road;
- points of transition which create critical glare angles between opposing vehicles;
- locations where nighttime crash rates are unusually high; and
- any location where conflicting light sources cause a distorted or confusing view of the driver's field of vision.

IDOT has not adopted specific warrants for the use of glare screens. The typical application, however, is on urban freeways with narrow medians and high traffic volumes. Another application is between on/off ramps at interchanges where the two ramps adjoin each other. Here, the sharp radii and the narrow separation may make headlight glare especially bothersome. The designer should consider the use of glare screens at these sites. A key element warranting their use is the number of public complaints IDOT may have received for a highway section.

38-7.05(c) Types

The following describes those glare screens used by the Department:

- 1. <u>Concrete Barrier Extension</u>. If both a concrete barrier and glare screen are warranted, the designer may extend the height of the concrete barrier to 50 in (1295 mm), which will effectively block most headlight glare. See the *Illinois Highway Standards* for details. If there is a high percentage of trucks, this height may need to be increased.
- 2. <u>Paddles</u>. As an alternative to the extended concrete barrier, a series of commercially available plastic paddles may be mounted to the standard height concrete barrier to serve as a glare screen.
- 3. Chain Link Fence. If a median barrier is not warranted but a glare screen is warranted, the designer should install a chain link fence glare screen using a fabric woven with a maximum 1 in (25 mm) opening between parallel wires. In addition to alleviating glare, the fence will control access across the median. This type of glare screen is also effective in controlling glare between the mainline and adjacent frontage roads because an access control fence is usually required.

38-7.05(d) Design

The following applies to the design of a glare screen:

- 1. <u>General</u>. Glare screens must not be used as a wind or snow shield nor should they detract from the aesthetics of the highway. However, they should be durable and easy to maintain.
- 2. <u>Cutoff Angle</u>. Glare screens should be designed for a cutoff angle of 20°. This is the angle between the median centerline and the line of sight between two vehicles traveling in opposite directions. See Figure 38-7F. The glare screen should be designed to block the headlights of oncoming vehicles up to the 20° cutoff angle. On horizontal curves, the design cutoff angle should be increased to allow for the effect of curvature on headlight direction:

Cutoff Angle (in degrees) =
$$20 + \frac{5729.6}{R}$$
 (US Customary)

Cutoff Angle (in degrees) =
$$20 + \frac{1746.8}{R}$$
 (Metric)

where R = radius of horizontal curve in feet (meters).

- 3. <u>Horizontal Sight Distance</u>. Glare screens may reduce the available horizontal sight distance. For curves to the left, the designer will need to check the middle ordinate to determine if adequate stopping sight distance will be available. See Section 32-4.
- 4. <u>Sag Vertical Curves</u>. When determining the necessary glare screen height, the designer may ignore the effect of sag vertical curvature.
- 5. <u>Height of Eye</u>. The average driver's eye height is 3.5 ft (1080 mm) for passenger vehicles and 7.6 ft (2.3 m) for large trucks. These heights are average and must be adjusted when determining the extreme conditions.
- 6. <u>Glare Screen Height</u>. The upper and lower elevations of the glare screen must be such that light does not shine over or under the barrier. The height of glare screens may be established by examining the following factors:
 - height of driver's eye in relation to the pavement,
 - height of the headlights of various size vehicles in relation to the pavement, and
 - changes in elevation across the entire roadway width including the median.

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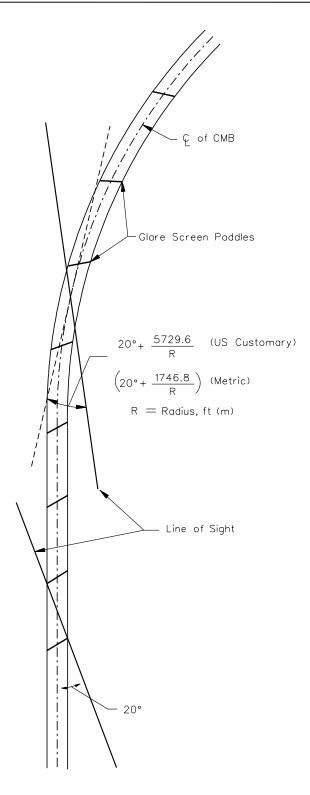
Example 38-7.05(1)

Given: Six-lane divided highway

12 ft travel lanes

2% pavement cross slope

5 ft median width



CUTOFF ANGLE FOR GLARE SCREENS
Figure 38-7F

Problem: Determine the upper and lower elevations of the glare screen.

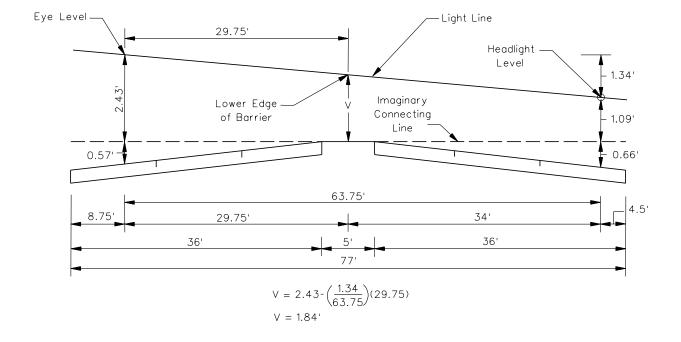
Solution: First, determine the lower elevation based on the following factors:

- 1. The most severe condition is two sport cars traveling in opposite directions each using the right-hand lane.
- 2. The eye level of the drivers is 3 ft above the pavement.
- 3. The lower edge of the sport car's headlights is 1.75 ft above the pavement.
- 4. The driver's eyes are approximately 8.75 ft from the outer edge of the traveled way.
- 5. Figure 38-7G presents the determination of the lower edge of the glare screen.

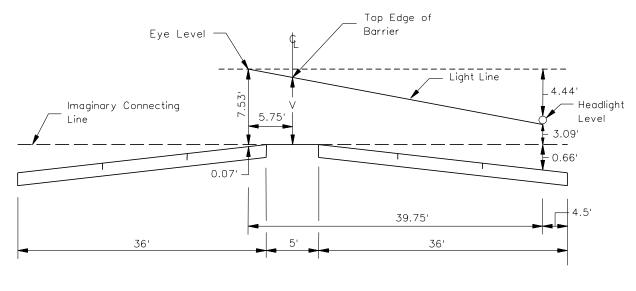
Next, determine the upper elevation based on the following factors:

- 1. The most severe condition is two large trucks traveling in opposite directions, one using the right-hand lane and the other using the left-hand lane.
- 2. The eye level of the drivers is approximately 7.6 ft above the pavement.
- 3. The lower edge of the truck headlights is 3.75 ft above the pavement.
- 4. The eye of the driver using the left-hand lane is approximately 5.75 ft from the median centerline.
- 5. The left headlight of the truck using the right-hand lane is approximately 4.5 ft from the outer edge of the traveled way.
- 6. Figure 38-7H presents the determination of the upper edge of the glare screen.

For most locations, it is not necessary to use this upper level. See Section 38-7.05(c).



LOWER ELEVATION OF GLARE SCREENS (Example 38-7.05(1)) Figure 38-7G



$$V = 7.53 - \left(\frac{4.44}{39.75}\right) (5.75)$$

$$V = 6.89'$$

UPPER ELEVATION GLARE SCREENS (Example 38-7.05(1))

Figure 38-7H

38-8 IMPACT ATTENUATORS (Crash Cushions)

38-8.01 **General**

Impact attenuators (crash cushions) are protective systems that prevent errant vehicles from impacting hazards by either decelerating the vehicle to a stop after a frontal impact or by redirecting it away from the hazard after a side impact. They operate on the basis of energy absorption or energy transfer. Impact attenuators are adaptable to many roadside hazard locations where longitudinal barriers cannot practically be used.

38-8.02 **Warrants**

Impact attenuator warrants are the same as barrier warrants. Once a hazard is identified, the designer should first attempt to remove, relocate, or make the hazard break away. If the foregoing is impractical, then an impact attenuator should be considered.

Impact attenuators are most often installed to shield fixed-point hazards which are close to the traveled way and where head-on impacts are probable. Examples include exit gore areas (particularly on structures), bridge piers, and median barrier ends. Impact attenuators are often preferable to a roadside barrier to shield these hazards. Site conditions and costs will determine whether to use a barrier or impact attenuator.

38-8.03 Impact Attenuator Types

The following sections discuss the impact attenuator types used by IDOT. The designer should note that all of the operational systems are patented. Contact the manufacturer for additional information on impact attenuator installations.

38-8.03(a) Energy Absorbing Devices

These types of impact attenuators operate on the principle of absorbing the energy of the vehicle through the use of bays or modules filled with crushable or plastically deformable materials. Some energy is also absorbed by the vehicle as the front end of the vehicle is crushed on impact. Impact attenuators of this type require a rigid back-up support to contain the forces created by the deformation of the device. Most devices of this type capture the vehicle in a frontal impact. For side impacts, the vehicle is smoothly redirected by means of side panels and/or cables. Vertical and lateral restraint of the device is also required.

38-8.03(b) Energy Transfer Devices

These systems operate by transferring the energy of the impacting vehicle to an expendable mass of material contained in the device. A typical device of this type is an array of sand-filled plastic

modules. Sand barrel configurations meeting NCHRP 350 requirements are available to accommodate various speeds and widths. Information is available from the various manufacturers regarding their NCHRP 350 accepted configurations. This system has a low initial cost but relatively high maintenance cost. Therefore, sand barrel systems are best suited for low-impact locations (e.g., fewer than 3 hits a year). In addition, it may be the only practical impact attenuator for very wide hazards.

The system requires no back-up support. However, the barrels have no redirective capability, and it generates considerable debris upon impact. The exterior modules must be laterally offset at least 2.5 ft (750 mm) from the corner of the hazard.

38-8.03(c) Other Systems

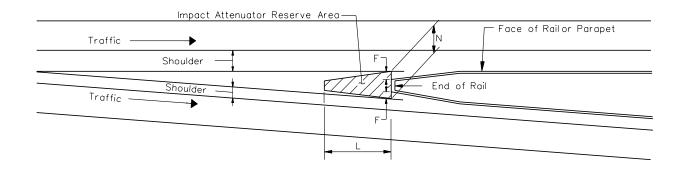
There are several other impact attenuators available; see the *Roadside Design Guide*. A proposed use of new or experimental systems must be coordinated with BDE.

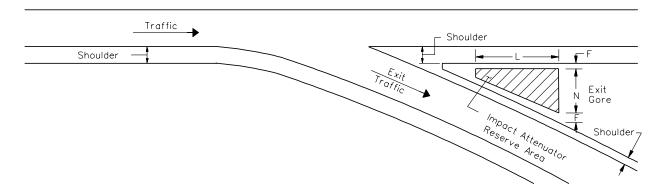
38-8.04 Impact Attenuator Selection

The selected impact attenuator must be compatible with the specific site characteristics. Often, more than one of the operational systems will be adaptable to the site. Therefore, the designer must exercise judgment in impact attenuator selection considering:

- type and width of hazard;
- space available for installation of the system (see Figure 38-8A);
- whether the hazard to be shielded is located in a high- or low-risk impact area;
- initial, maintenance, and restoration costs; and
- ease or difficulty of restoration of the system after impact.

Figure 38-8B summarizes the advantages and disadvantages of the impact attenuator systems used by IDOT. There are many other factors which will influence the selection of an impact attenuator for a given site. Therefore, the designer should only use this figure as a rough indicator to select a system.





Danima On and	Dimensions for Impact Attenuator Reserve Area (feet)								
Design Speed On Mainline	Minimum								
(mph)	Restricted Conditions		Unrestricted Conditions			Preferred			
	N	L	F	N	L	F	N	L	F
30	6	8	2	8	11	3	12	17	4
50	6	17	2	8	25	3	12	33	4
70	6	28	2	8	45	3	12	55	4

	Dimensions for Impact Attenuator Reserve Area (meters)								
Design Speed	Minimum								
On Mainline (km/h)	Restricted Conditions		Unrestricted Conditions			Preferred			
	N	L	F	N	L	F	N	L	F
80	2	2.5	0.5	2.5	3.5	1	3.5	5	1.5
90	2	5	0.5	2.5	7.5	1	3.5	10	1.5
100	2	8.5	0.5	2.5	13.5	1	3.5	17	1.5
110	2	11	0.5	2.5	17	1	3.5	21	1.5

RESERVE AREA FOR IMPACT ATTENUATORS

Figure 38-8A

SYSTEM	ADVANTAGES	DISADVANTAGES
Energy Absorbing Devices	 Little or no debris after a hit. Ease of maintenance after a hit. Some attenuation capacity after a hit. Relatively low maintenance cost to repair after a hit. Coffin corner protection and side hit redirection. Adaptable to very narrow obstacles 	 High initial cost. Considerable site preparation (e.g., back-up structure). Width of protection limited by width of units available.
Energy Transfer Devices (Sand Barrels)	 Relatively low initial cost. Ease of installation. Little or no site preparation required. Versatile; can be used to cover a large area. 	 Considerable debris after a unit is hit requiring clean-up. Relatively high maintenance cost to repair after hits (damaged barrels must be replaced). Generally, no residual attenuation capacity after a major hit. No side redirection and little or no "coffin corner" protection. Considerable inventory of parts and space for replacements required. Modules may "walk" when placed on structures.

IMPACT ATTENUATOR TYPES (Advantages and Disadvantages)

Figure 38-8B

38-8.05 Impact Attenuator Design

Once an impact attenuator has been selected, the designer must ensure that its design is compatible with the traffic and physical conditions at the site. The following sections will provide criteria for the basic input parameters into impact attenuator design. The designer should contact the manufacturer of the system for the detailed design of the impact attenuator.

38-8.05(a) Deceleration

For all safety appurtenances, acceptable vehicular deceleration is determined by the occupant impact velocity as measured from full-scale crash tests. All impact attenuators must meet the following parameters for occupant reaction:

- 1. <u>Vehicular Weight</u>. The impact attenuator must accommodate vehicles weighing between 1800 lbs (820 kg) and 4500 lbs (2000 kg).
- Vehicular Speeds. For freeways, use the design speed of the facility. For rural non-freeways, use the posted speed limit of the facility with a minimum of 50 mph. For urban non-freeways with posted speeds < 40 mph, use the posted speed plus 5 mph. For 40 mph and over, use the posted speed. For urban freeways with a posted speed of 40 mph or more, use the posted speed.</p>
- 3. <u>Deceleration Forces (Occupant Reaction)</u>. Figure 38-8C summarizes the accepted criteria.

38-8.05(b) Design Procedures

To determine the appropriate number of bays for the energy absorbing devices, the designer should contact the manufacturer for more information.

38-8.05(c) Side Impacts

The impact attenuator design should allow for safe side impacts. All systems used by IDOT, except the sand barrels, are designed to redirect impacting vehicles on the side. Figures 38-8D and 38-8E illustrate two methods to modify the sand barrel design to accommodate angle impacts. Figure 38-8D illustrates how the modules may be shifted to afford attenuation at the end points and redirection along the sides of the hazard by the use of guardrail. Figure 38-8E illustrates where the side of the hazard and available space are such that full protection, through attenuation only, can be provided by the use of additional modules to widen the standard array. Although the entire area of a hazard must be shielded from angle impacts either by attenuation or

redirection, the permissible attenuation may be varied to optimize space and economy. Various combinations of deceleration intensity and angle impacts, within the design criteria limits, will be acceptable when based on appropriate site or cost limitations.

Evaluation Factor	Component	Preferred	Maximum	
Occupant Impact Velocities	Longitudinal and Lateral	30 ft/sec (9 m/s)	40 ft/sec (12 m/s)	
Occupant Ride-down Acceleration	Longitudinal and Lateral	15 g's*	20 g's *	

^{*} g = 32.16 ft/s/s (9.81 m/s/s). Maximum acceleration is 10 milliseconds.

Note: These criteria are from NCHRP 350 Recommended Procedures for the Safety Performance Evaluation of Highway Features.

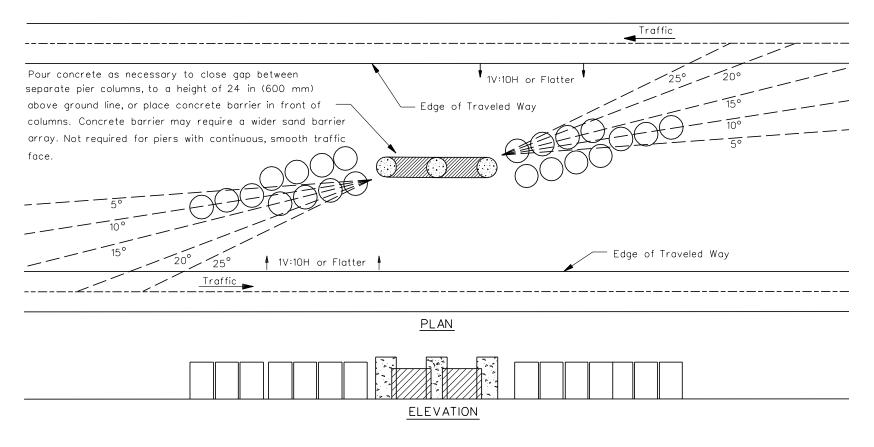
ACCEPTABLE OCCUPANT REACTION (Impact Attenuators)

Figure 38-8C

38-8.05(d) Placement

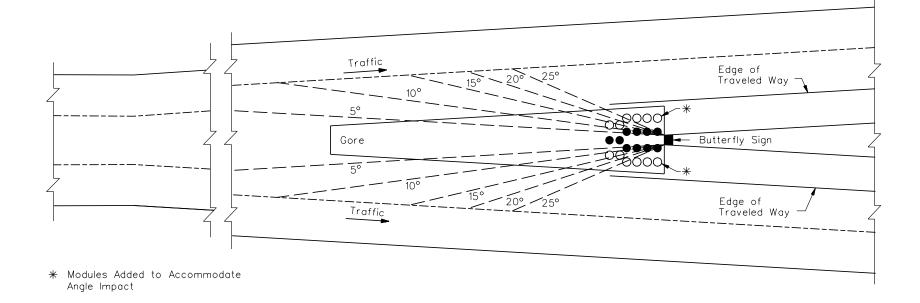
Several factors should be considered in the placement of an impact attenuator:

- 1. <u>Level Terrain</u>. All impact attenuators have been designed and tested for level conditions. Vehicular impacts on devices placed on a non-level site could result in an impact at the improper height which could produce undesirable vehicular behavior. Therefore, the attenuator should be placed on a level surface or on a cross slope not to exceed 5%.
- 2. <u>Curbs</u>. No curbs higher than 2 in (50 mm) should be present on new projects at impact attenuator installations. On existing highways, all curbs higher than 2 in (50 mm) should be removed at proposed installations if feasible.
- 3. <u>Surface</u>. A paved, bituminous or concrete pad should be provided under the impact attenuator. The base should be 2 ft (600 mm) wider than the array.



TYPICAL INSTALLATION OF A FREESTANDING, SAND-FILLED, CONTAINER-TYPE IMPACT ATTENUATOR IN MEDIAN

ANGLE IMPACT DESIGN FOR SAND BARRELS Figure 38-8D



TYPICAL INSTALLATION OF A FREESTANDING, SAND-FILLED, CONTAINER-TYPE IMPACT ATTENUATOR SYSTEM IN A MAJOR FORK

ANGLE IMPACT DESIGN FOR SAND BARRELS Figure 38-8E

- 4. <u>Elevated Structures</u>. The unanchored sand barrels may walk or crack due to the vibration of an elevated structure. This could adversely affect its performance, and the energy transfer device should not be used on elevated structures.
- 5. Orientation. The impact attenuator should be oriented to accommodate the probable impact angle of an encroaching vehicle. See Figures 38-8D and 38-8E for sand barrels. This will maximize the likelihood of a head-on impact. However, this is not as important for impact attenuators with redirective capability. The proper orientation angle will depend upon the design speed, roadway alignment, and lateral offset distance to the attenuator. A maximum angle of approximately 10°, as measured between the highway and impact attenuator longitudinal centerlines, is considered appropriate.
- 6. <u>Location</u>. The system must not infringe on the traveled way. There should be a minimum of 2 ft (600 mm) between the attenuator system and the hazard to allow access to the system.
- 7. <u>Bridge Joints</u>. Avoid the placement of impact attenuators over bridge expansion joints or deflection joints in deep superstructures because movement in these joints could create destructive strains on the system's anchor cables.
- 8. <u>Transitions</u>. Transitions between systems and backwalls, bridge rails, or other objects should be smoothly shaped to lessen the possibility of vehicular snagging. The yielding characteristics of the system should be considered when determining the transition.

38-9 REFERENCES

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- 7. NCHRP 158 Selection of Safe Roadside Cross Sections, Transportation Research Board, 1975.
- 8. NCHRP Synthesis 66 *Glare Screen Guidelines*, Transportation Research Board, December 1979.
- 9. NCHRP 350 Recommended Procedures for the Safety Performance Evaluation of Highway Features, Transportation Research Board, 1993.
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- 13. "Development of an Economic Model to Compare Median Barrier Costs," Bryden, Bruno and Fortuniewicz, NYSDOT, July 1986.